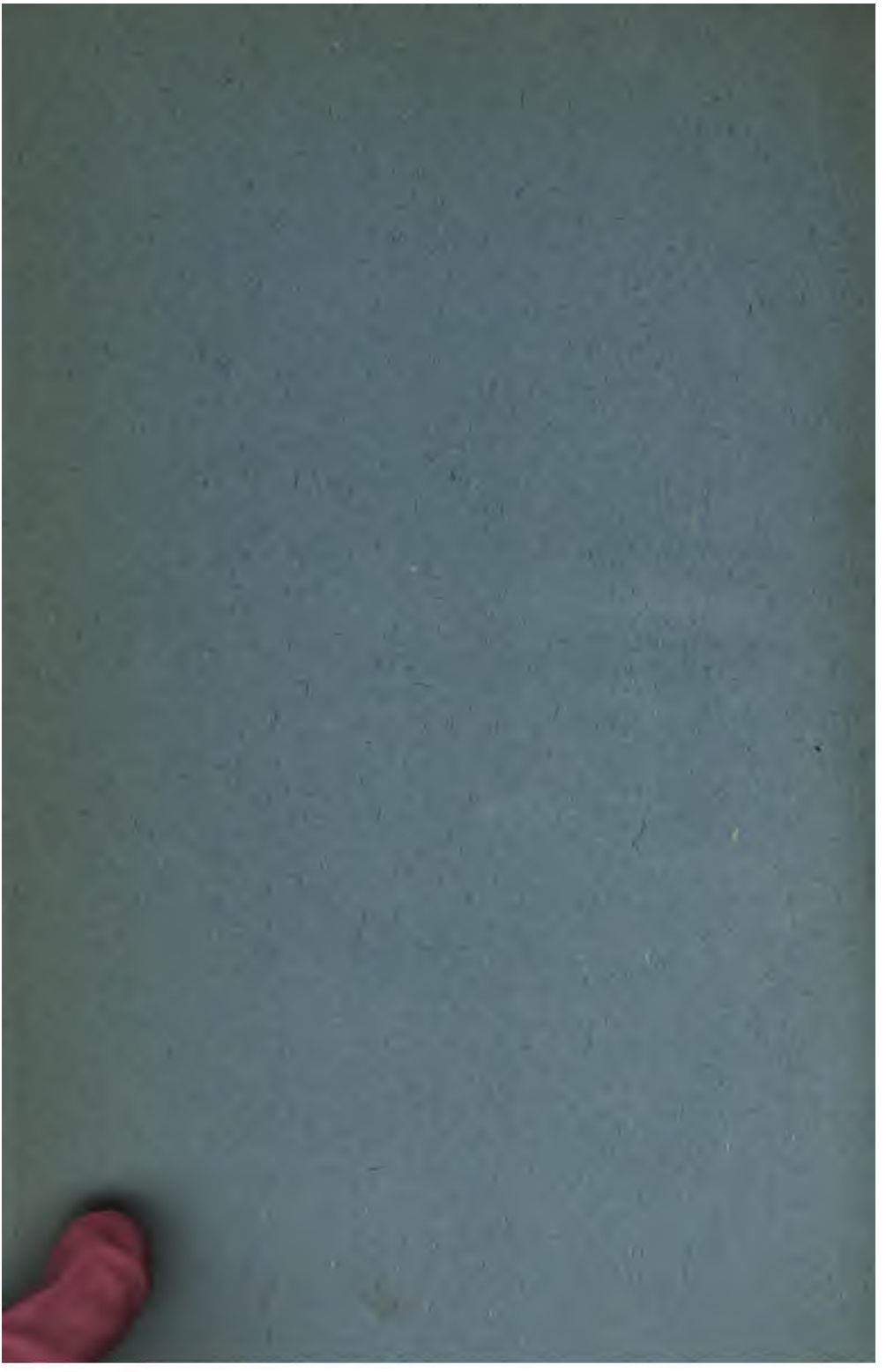

PHYSIOLOGICAL

THERAPEUTICS:

A NEW THEORY.

By THOMAS W. POOLE, M.D., M.C.P.S., Ont.

Until we rely "upon logical deductions rather than on what are called 'time-honored facts'—because they have been asserted for a century or two, though not facts at all—the practice of our profession will not improve."—Dr. T. Inman.

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Dedication.

TO JOSEPH WORKMAN, ESQ., M. D., M.C.P.S., ONT.,

FORMERLY PRESIDENT OF THE MEDICAL FACULTY OF THE TORONTO SCHOOL OF MEDICINE; LATE MEDICAL SUPERINTENDENT OF THE PROVINCIAL LUNATIC ASYLUM, TORONTO; PRESIDENT OF THE TORONTO MEDICAL SOCIETY; EX-PRESIDENT OF THE CANADA MEDICAL ASSOCIATION.

This Essay

Is respectfully inscribed: In admiration of the valuable services he has rendered to Medical and Sanitary Science, as a Skilful Physician, a learned and eloquent Teacher of Medicine, and a warm Friend of Humanity.

By a former pupil,

THE AUTHOR.

PREFACE.

What is presented to the reader in these pages, is not a new system of medical practice; but it is a new theory of the inter-relations of nerve-force and muscular tissue throughout the body, including the relations of nerve and muscle in the coats of arteries whereby their calibre is regulated; and of the mode of action of that large class of drugs which operate through the medium of the nervous system.

The facts presented are not necessarily new; but the interpretation or explanation here given of them, differs materially from the opinions generally accepted by the Medical Profession.

If an apology be necessary for the apparent boldness of venturing to call in question accepted theories, with which great names are identified, perhaps beside the general plea of progressive ideas, the special justification may be urged, that the facts, experiments, and observations upon which this new departure is based, are drawn from the published works of our standard authorities in physiological, electrical and medical science, including those of recent times.

The assertion of the inherent and independent contractile power of muscular tissue, and the function of nerve-force as a restraining power over it, is not new; but has long ago found a place—though an obscure one—in medical literature. For the arguments by which this assertion is sustained; for the new doctrines embodied in the other "general principles"; and for the application of the facts presented in support of them, we are solely responsible.

Fully conscious that our task has been very imperfectly performed, carried on as it has been during the brief leisure and frequent interruptions of an active practice, and that our theory will have to sustain the ordeal of adverse criticism; we are, nevertheless, of

opinion, that from its practical importance, and the weight of evidence in its favor, we are justified in submitting it to the Profession.

Our references to authorities are perhaps more numerous than are ordinarily required ; but in a work of this kind, we ask the reader to take as little as possible on trust from us, and therefore have not spared to support the facts mentioned by ample references to our sources of information.

The advancement of medical science will probably shew that some of the views expressed in this essay are untenable ; we are not without hope that it may confirm and establish others.

Lindsay, Ontario, Canada, February 17th, 1879.

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INTRODUCTION.

GENERAL PRINCIPLES ASSERTED.

The general principles which underlie what follows, and which we hope to substantiate hereafter, may be stated thus :—

(1) The muscles and muscular tissues, generally, of the body, are endowed with an inherent contractile power of their own, independent of nervous influence ; but this contractile power of the muscles is regulated for voluntary purposes, through the agency of the nervous system.

(2) The influence exerted by the nervous system in its relations with muscular tissue, is that of a *restraining*, and not that of a compelling power. Nerve-force, then, so far from being the ally, is the direct antagonist of muscular contractile power ; and the latter displays itself to the best advantage in proportion as the influence of the former is withdrawn.

(3) Electricity is not a stimulus to nerve or muscle. On the contrary, its action is that of a sedative, anæsthetic and paralyzer to nerve tissue. It is through this quality of its action that it soothes pain ; while its "tonic" effects depend solely on the indirect improvement in nutrition brought about by an infinite number of contractions and relaxations of muscular fibre.

These spasmodic contractions depend on the same condition as muscular spasms otherwise occurring :—that is to say,—they depend upon a partially paralyzed condition of some portion of the motor nervous system, setting muscular fibre free to contract, and not on any exalting or "vitalizing" quality whatever.

(4) The contractions induced more especially in unstriped muscular fibre by ergot of rye, follow the same rule or law as irregular muscular contractions otherwise occurring :—that is to say,—they depend on the withdrawal of nerve-force, and the cessation of its ordinary restraint upon the contractility of muscular fibre, which being thus left free to act, passes into a state of contraction.

(5) The muscular fibres of the middle coat of the arteries, in the normal state, tend continually to exert their inherent contractile power in lessening the calibre of these vessels, and so diminishing blood supply:—while the vaso-motor nerves, ramifying among those muscular fibres, have for their function the restraining of this contractile power; and when predominant, aided by blood pressure, induce dilatation of the blood-vessels with correspondingly increased vascular activity.

(6) Certain drugs, by modifying the activity of the vasomotor nerves, (increasing their power by nutritive changes in the cells which generate nerve-force, or paralyzing the nerves themselves and so arresting their functional activity,) cause an increase or diminution of the calibre of the blood-vessels; and so exert an important influence, not only over the nutrition and temperature of parts, but in controlling congestive and inflammatory processes, and so restoring normal circulatory activity.

We now proceed to consider, in turn, the several general principles or propositions just enumerated; to support them as best we may, from the writings of the recognized authorities, whose labors have built up the hypothesis we are to oppose, and from such general facts and considerations as we have been able to gather; and to present the results to the reader for a just and unbiasssed consideration.

CHAPTER I.

MUSCULAR CONTRACTILE POWER INDEPENDENT OF NERVOUS INFLUENCE.

1. *First general principle.*—The muscles and muscular tissues generally, of the body, are endowed with an inherent contractile power of their own, independent of nervous influence; but this contractile power of the muscles is regulated, for voluntary purposes, through the agency of the nervous system.

2. Dr. Carpenter is our chief authority here. He says:—"The opinion that contractility cannot be an endowment of an organized structure, is at once negatived by the fact that in plants we find tissues endowed with a high degree of contractility, and manifesting this property without any possible intervention of a nervous system, &c."*

Again,—"In the lower class of animals, there is good reason to believe that contractility is more widely diffused through their tissues than nervous agency can be."†

"Rythmical contractions take place in the rudimentary heart, when as yet no nerves or ganglia have made their appearance."‡

*Human Physiology, 5th Am. Ed., (Smith) p. 324. †Ibid. ‡Ibid.

"The human fœtus has come to its full size, so that its heart must have regularly acted, without either brain or spinal cord."*

Referring to spontaneous movements of cilia, of the heart and uterus, he says :—"When every source of excitement is excluded, we cannot but perceive that these actions take place with a *spontaneity* which can scarcely be accounted for in any other way than by considering them as expressions of the vital activity of the component cells of these forms of muscular tissue. . . .

. It is impossible to assign any other cause for the movement of the heart under such circumstances, than the *attributes inherent in the tissues which perform it.*"†

In his concluding remarks on certain muscular movements which have been observed after death, especially from cholera and yellow fever, this distinguished author says :—"Many circumstances indicate that these movements were due *to the inherent contractility of the muscles*, and were not in any degree dependent upon the operations of the nervous system."‡

Dr. Carpenter further assures us that "the intestinal tube, from the stomach to the rectum, is not dependent upon the nervous centres, either for its contractility or for its power of exercising it; but is enabled to propel its contents by *its own inherent powers.*"‖

Drs. Todd and Bowman express the opinion that "contractility is a property of the living muscular substance *as such.*"§ Further quotations of similar import will appear as we advance.

3. We frankly admit that these opinions, conclusive as they appear, were not intended by their authors to support a thesis such as is here enunciated. But they are not of less value on that account. Indeed it is not a little singular that physiologists in admitting so much, have still thought it necessary to supplement this avowed inherent contractile power with an assumed "stimulus" from the nervous system to evoke its action. But such was the dominant idea of the theory of the day, and the general facts of muscular contraction were interpreted accordingly.

It is the object of these pages to show that this property of muscular contractility is capable of manifesting itself *in the absence* of any special natural or artificial stimulant : that is, that muscular contractility displays its effects in the body, when simply left to itself, and not restrained by nervous influence (as in the next proposition we assert it to be) in the normal state of the system.

What, we ask, is the meaning of the term "inherent," which our physiologists so generally and so often apply to the contractile power of muscle? Philologists define it as "existing inseparately," "implanted by nature," "not adventitious," "inborn," "naturally pertaining to."—(Worcester.) Its synonyms are, "innate," "inborn," "native," "natural," "inbred," &c.—(Webster.) Now an *inherent*

*Human Physiology, p. 324. †Ibid, p. 131. ‡Ibid, 328.
‖Ibid, pp. 409, 410. §Physiol. Anat., p. 179.

contractile *power*, which is dependent on some other "power" for its operation is an absurdity. A locomotive has not an inherent power of motion. Gunpowder has not an inherent power of explosion. The admission of an inherent contractile power, is tantamount to an admission of the ability to use that power. Our physiologists, then, have entirely mistaken the meaning of the term they freely use, or they admit, *pro tanto*, the claim we put forward for this tissue.

4. Besides, apart from nerve-force, the several agents referred to in this connection as assumed "stimulants" to muscular contractile power, have certainly been misnamed, and really exert an influence of an opposite kind. In regard to one of these, especially, and the principal one—electricity—we hope to show, by and by, to the satisfaction of the reader, that so far from being a "stimulant" or an "excitant," it is truly a paralyzer of *nervous tissue*, and tends proportionately to release the power of the muscle, and so to favor its contraction.

5. In pursuing this subject further, it will be convenient to consider it under the following phases :—

(*a*) Active (voluntary) contraction.
(*b*) Passive contraction (or tone).
(*c*) Irregular (involuntary) contraction, (spasm, &c.)
(*d*) Relaxation or flaccidity, (syncope, &c.)
(*e*) Rigor mortis.

6. (*a*) *Active (voluntary) contraction.*—It seems desirable to remind the reader that motor nerve-force is not the only factor which has an important influence on muscular contraction. Sir C. Bell is the earliest authority for the statement that "no voluntary action can be performed without the assistance of a *guiding sensation.*" This has been called "the muscular sense." "In the majority of cases, the guiding or controlling sensation is derived from the muscles themselves, of whose condition we are rendered cognizant by the sensory nerves with which they are furnished."*

In certain cases one of the special nerves may supply a defect of the muscular sense and *vice versa*. "Thus, in complete anæsthesia of the lower extremities without loss of muscular power, the patient is as completely unable to walk, as if the motor nerves had been paralyzed, unless the defective sensorial guidance be replaced by some other ; and in similar affections of the upper extremities there is a like inability to raise a limb or to sustain a weight. But in such cases the deficiency of the "muscular sense" may be made good by the visual. Thus the patient who cannot feel either the contact of his foot with the ground, or the muscular effort he is making, can manage to stand if he *look* at his limbs ; and the woman who cannot feel the pressure of her child upon her arms, can yet sustain it as long as she keeps her eyes fixed upon it, but no longer—the

*Dr. Carpenter's Human Physiology, p. 722.

muscles ceasing to contract, and the limbs dropping powerless the moment that the eyes are withdrawn from it."*

7. We have introduced these considerations here for the purpose of showing, that while on the theory here advocated the motor nerves and muscular fibre are natural antagonists, yet the latter is not divorced from the influence of the nervous centres, even as regards the exercise of its contractile power. For not only by means of trophic or nutritive nerves (already referred to) but also, as now shown by means of the afferent nerves, transmitting to the centres "a guiding sensation" from the muscles, these latter are kept *en rapport* with the central ganglia, and thus the power of co-ordination of the different parts of the muscular apparatus is duly maintained. Thus the regularity and efficiency of muscular motion in response to the will is provided for, without any apparent necessity for guidance or direction from the motor nerves; from which we infer that any assumed "stimulus" from these nerves is not a necessity in co-ordinate muscular movements, and as a consequence that all the conditions of normal muscular activity can be fulfilled, and are amply provided for, even though the motor nerves be regarded as exercising solely, a restraining and not a compelling power towards the muscles.

8. It is also necessary to bear in mind that when we *will* to make a certain movement, we are utterly unconscious of the selection of a particular muscle or of any number of muscles on the action of which the movement depends. What the will is concerned in is simply *the result;* the selection and combination of muscular movements required to bring about the desired result, not being effected by the will but by the intermediate agency of the automatic centres, the sensory ganglia. It is fortunate for us that this is the case, for otherwise we would be dependent upon a knowledge of anatomy for the power to perform the simplest muscular movement.

Dr. Carpenter, who is our authority for this statement, illustrates it very well, by the manner in which the muscles of the larynx are made to act in the production of vocal sounds. The will has no direct power over the muscles of the larynx, as is shown by the fact that we cannot raise or depress the larynx as a whole, nor move its cartilages, nor extend or relax the vocal ligaments, by simply *willing* to do so, no matter how strongly. But we conceive of a tone *to be* produced and we *will* to produce it; a certain combination of the muscular actions of the larynx then takes place in exact accordance one with another, and the predetermined tone is the result.† It is the same with other muscles of the body; and the *sense of effort* which we naturally refer to the muscles, in willing them to contract, is nothing more than "the muscular sense," already referred to.‡

*Dr. Carpenter's Hum. Physiology, p. 722. †Physiology, pp. 726-7. ‡Ibid, p. 726.

9. Now it may be claimed on our part that the motor nerve impulse or molecular change, which originates the voluntary contraction of muscle, may as readily be one which relieves the muscle from previous restraint, as one which supplies a "stimulus" to the muscle to contract. For, as just shewn, this impulse and the desired result are all that the will really has to do with the matter; the motor ganglia, guided by the muscular sense directing the impulse to the proper muscle, the contraction of which does the rest.

10. The force or moderation with which voluntary muscular contraction may be made to display itself, as in striking a gentle or a heavy blow, does not in the least embarrass this view of the case. For where a powerful impulse is directed by the will to ensure a heavy blow, as the result of the mental act, the release of a greater number of fasciculi of a muscle, (than for a lighter blow), and the simultaneous calling into play of a greater number of muscles, and doing so with greater suddenness, fully accounts for the increased result produced. Indeed this is the very explanation authoritatively given for the apparently increased strength of muscular power displayed by maniacs, or by persons laboring under great mental excitement, which in these cases is not attributed to increased nerve-force "stimulating" muscular contraction. Besides, it is distinctly avowed that "there is no evidence that muscular irritability [that is, its power of contracting under an assumed stimulus] can be increased by any cause operating through the nervous system."*

Furthermore, modern research shows that in the cases referred to, the appearance of increased strength is delusive; and that the condition of the nervous centres is one of weakened rather than of increased power. Thus Dr. Anstie bears witness to "the incredible violence and muscular strength of many patients who are sinking into a state of general paralysis of the insane," and who are best treated by food and stimulants.†

11. It has been stated by Dr. Carpenter, (in apparent antagonism to the last quotation from his Physiology), that "stimulating agents, as the moderate use of alcohol, nitrous oxide, opium, &c., which temporarily increase muscular power, do so by *primarily exciting the nervous system.*"‡

The action of these agents will be discussed elsewhere. It may suffice to remark here, that granting all that is here stated—that alcohol in moderate doses *excites* the nervous system in healthy states—that excitation may serve simply like the mental or maniacal excitement just mentioned, to call into play a greater number of muscles, or to do so more promptly than in ordinary states; and like these conditions also, it is followed by a period of depression. The so-called food action of alcohol, especially in exhausting diseases, where great disintegration of tissue is going on, is of a

*Dr. Carpenter's Hum. Physiology, p. 322. †Stim. and Narcot., pp. 133-4.
‡Pysiol. p. 322.

different character, and is not attended by signs of stimulation ; so that it need not be further referred to here.

We think, then, that from the foregoing considerations, we are justified in concluding that in so far as active voluntary muscular contractions are concerned, there is nothing in the facts of the case at variance with our theory, and very much in favour of it, on sound physiological principles.

12. *(b) Passive muscular contraction.*—By this is meant that moderate contraction of muscles while at rest, which gives them a certain firmness, as contrasted with flaccidity ; and enables them to resist the equally passive contraction of their antagonists. Some physiologists have attributed the maintenance of this state to the influence of the spinal cord ; and certain experiments of Dr. M. Hall appear to support this hypothesis, which, however, is repudiated by Drs. Todd and Bowman, as the following quotation will show :—

"It has been supposed that the tone of the muscular system is maintained by the spinal cord. If by tone be meant what we have described as passive contraction, we can only remark that the phenomena which characterize that state are just as obvious in muscles taken from animals recently deprived of the spinal cord as in others ; and that the analogous state, rigor mortis, comes on as distinctly when the spinal cord and brain have been removed as if they were untouched. *Healthy nutrition, in our opinion, supplies all the conditions necessary for the maintenance of the tone or the passive contraction ;* nor is the spinal cord (although itself healthy) able to preserve the tense condition of the muscles, if they are not well nourished. The removal of the spinal cord indeed, immediately produces a flaccid state of the muscles of the limbs ; but this is owing to the immediate cessation of the slight degree of active contraction necessary to maintain a certain posture. A decapitated frog will continue in the sitting posture through the influence of the spinal cord ; but immediately this organ is removed, the limbs fall apart, *from the loss of the controlling and co-ordinating influence of the nervous centres.*"

"After these remarks it is scarcely necessary to add, that we must enter our protest against the doctrine which assigns the spinal cord as the source of muscular irritability. This doctrine, indeed, has but slender support either in reason or experience. *It is contrary to all analogy to assign to one tissue the power of conferring vital properties on another.* If bone, tendon, and cartilage have their distinctive properties, they possess them in virtue of some peculiarity inherent in their mode of nutrition, and do not derive them from any other texture. And *surely it is too much to suppose that a tissue like muscle, so complex in its chemical composition, and so exquisitely organized for the developement of its proper force, should be dependent on the nervous system, or a portion of it, for its contractile power !*"*

*Physiol. Anat., pp. 302-3.

Drs. C. Handfield Jones and Edward H. Sieveking express a similar opinion. Writing of muscular contractility, they say :—"It has been supposed by some that the power or quality was not resident in the contractile tissue, but in the spinal cord, from which it was conveyed by the nerves to the muscles ; but this view seems quite contradicted by observation and by analogy."*

13. Now this is very strong and unexceptionable authority in support of our theory ; for although these gentlemen, in accordance with the dominant idea of the day, regard this inherent muscular contractility as acted on by nervous influence, of the nature of a "stimulus," the theory here advocated admits the influence of nervous agency over the muscles to an equal extent,—only *attributing to it a different mode of action*,—a release of muscular force from restraint—which accords well with its inherent contractile power, instead of a motive power to contraction, which is unnecessary, seeing this property is already existing in the muscular tissue itself.

14. If the reader is not yet prepared to agree with us, as to the *independent*, as well as *inherent* contractile power of muscular tissue, we ask him, (using the phraseology of Drs. Todd and Bowman) if it be *too much* to suppose that a tissue so complex, so exquisitely organized, and so highly endowed as muscle, should be depending on the *nervous system* for the *use* of its distinguishing property,—is it not *a fortiori, too much*, to suppose that it is depending on other extraneous and accidental "stimulants"—such as the prick of a pin, the corrosion of an acid, or the chance proximity of a galvanic battery, for the exercise of that power ?

15. On the theory we present, the passive contraction of muscle is amply accounted for by the moderate antagonism between nerve-force, tending to relax the muscle, and its own inherent contractile power which tends to shorten it. Both forces here are passive, or in operation to their minimum extent, and mutually antagonize each other,—thus maintaining a balance of power.

16. *Irregular (involuntary) muscular contraction.*—If the balance of power just referred to, be disturbed by any cause tending to weaken nerve-force, a preponderance is given to the contractile power of muscular fibre, which exerts itself just in proportion to the extent that nerve-force is withdrawn. If the balance of power be persistently accorded to the muscular tissue, the spasm into which it passes will be of the "tonic" or continuous kind : on the contrary, if nerve-force is only intermittingly depressed, and the mastery alternates between the nerve and muscle, the spasms will be of the "clonic" kind,—that is, alternated with relaxation.

The primary failure of nerve-force in these cases, will be more fully discussed in the next succeeding chapter, to which this part of the subject more properly belongs ; and not only there, but through-

*Pathol. Anat., p. 38.

out the subsequent pages, ample proofs and illustrations will be furnished of the view here presented.

17. We cannot forbear, however, to make the following quotation from an eminent writer, now deceased, to whose luminous pages we are frequently indebted, and who has done much by patient research and thoughtful study to correct some of the popular medical errors of the day. Dr. Anstie makes the following remarks in summing up the narcotic effects of opium; but they are equally applicable to the effects in question, otherwise occurring:—

"1. To paralysis of the brain may be ascribed delirium, coma, emotional "excitement," involuntary memory, and involuntary fancy. 2. To paralysis of the spinal cord may be probably ascribed spasms, tetanic convulsions, paralysis of sensation, independent of loss of consciousness, tingling and creeping sensations on the surface, and actual pain. 3. To paralysis of the medulla oblongata may be probably referred clonic convulsions, tremor and shudderings, disturbances of respiration—*vomiting*. 4. To paralysis of the organic nerves of the heart may be probably ascribed the irregularity or cessation of the co-ordinated movements of that organ."*

Having separately dilated on these several groups, in a subsequent part of his work, he says:—"All these convulsive phenomena, which we have mentioned, are *constantly associated with more or less complete paralysis*."† Thus, then, spasms and irregular muscular contractions represent, not excessive nerve-force discharging itself along the motor nerves, but "a disturbed condition of the muscle, released only in part from the co-ordinating [nervous] influence which ordinarily governs its movements."‡

18. *Relaxation of muscle, (flaccidity).*—Why are the muscles flaccid and relaxed after a blow or a fall, causing syncope; after two minutes immersion under water; and after destruction of the spinal cord, by the process known as "pithing"? In the absence of any discoverable lesion, "something has happened, very difficult to explain, and yet evident in its results." What that something is, we no more know than we know how a heavy blow on a magnet deprives it of its magnetic power, and yet such is the case.‖

19. It is not impossible that an argument against our theory may be based on the fact in question, on the ground that the flaccidity follows on the apparent cessation of the "stimulus" of nerve-force, which it is alleged on the theory of the day, is the chief exciting cause of muscular contraction. We have, however, in a great degree anticipated this objection, in the lengthy quotation made in recent pages (§ 12), from Drs. Todd and Bowman. If the opinion of these eminent physiologists be held of value, the relaxation in question cannot fairly be attributed to a *withdrawal* of nerve-force from the muscles, for these gentlemen "protest" against Dr. M. Hall's

*Stimulants and Narcotics, p. 168. †Ibid, p. 198. ‡Ibid, p. 199.
‖ Brit. and For. Med. Chirur. Rev., Jan., 1876, p. 4.—Braith. Retros., July, 1876, p. 245.

doctrine, that the muscles owe their contractility to the spinal cord; and, as we have seen, Dr. C. Handfield Jones and Dr. Sieveking agree with them in that opinion. The effect in question cannot therefore be urged as an argument against our theory; for if muscular contractile power is independent of the nervous centres, injury of the latter of a paralyzing nature cannot cause a deprivation of muscular power. We are free to confess, however, that we desire a further reason for the flaccidity in question than the "loss of the controlling and co-ordinating power of the nervous centres." For it is not a little remarkable, that while in temporary syncope the contractile power of the muscles appears, sometimes greatly reduced or lost, they retain it in certain cases after somatic death of the body,* and perhaps in rigor mortis, under circumstances which appear much more unfavorable.

20. Physiological writers have but little to say on the question of "shock," and the direct causes which produce it. Dr. Carpenter, regarding nerve-force as a polar force, thinks there is a reversal of this force, or of its polarity, which occasions not simply a withdrawal or disturbance but an influence of an *opposite* kind, transmitted through the nervous centres, positively and directly antagonistic to the vital powers of the several tissues;† and that to this the effects of "shock" are attributable. This hypothesis implies that nerve-force is not only active in muscular contraction, (on the ordinary theory) but that it is equally active in muscular relaxation, from shock; since he specially disclaims mere negative results from the supposed "reversal" of the polarity of nerve-force. But it could hardly be an active agent in producing relaxation, except on the theory we suggest—as the antagonist to muscular contraction;—unless, indeed, muscular tissue possesses active power of relaxation as well as active power of contraction, for which, whatever justification might be found in organic muscles like the heart, there is no ground for the supposition in the case of voluntary muscles.

21. If we could accept the hint here given by Dr. Carpenter,—that nerve-force is active in this state; if indeed evidence were available that it is so active as to enable it to attain "a balance of power" over the muscle, a proximate cause for the relaxation would be apparent. Let us enquire further as to the condition of nerve-force in this and similar states.

22. In the first place, the fact is well established that unconsciousness or insensibility is no bar to the manifestation of the activity of nerve-force, as displayed in reflex actions of the spinal cord; which are sometimes more vigorously called forth by peripheral impressions which fail to reach the sensorium, and are consequently unfelt, than from prickings or impressions of which

*Dr. Carpenter's Human Physiology, p. 327. †Physiology, p. 350.

the subject was fully aware.* Were we to take the adherents of the orthodox theory on their own ground,—that muscular contraction is depending upon a "stimulus" from the nervous system,—and point them to the well authenticated and numerous instances of muscular contractions occurring after somatic death, consisting not only of the movements of individual muscles, but even of whole limbs,† they would feel compelled to admit the existence and activity of nerve-force, even here.

23. Dr. Carpenter refers to the general death of the body, under the name of somatic death, and to the subsequent cessation of all vital changes in the body as constituting molecular death, which latter sometimes follows speedily on the former but in other cases may be long postponed.‡

24. The behaviour of nerve and muscle to electricity after somatic and prior to molecular death, (which is immediately followed by rigor mortis,) proves that nerve-force is not extinct during the period in question. Electricity causes a contraction of the muscles so long as nerve-force is present in the nerve trunks or in their intra-muscular ramifications. It does this, as we shall show to the satisfaction of the reader in a future chapter, by *paralyzing the nerve*, and so setting the muscle free. *When nerve-force is extinct and electricity can paralyze it no further, it ceases to have any influence on muscular tissue, and this is true of the relations between nerve and muscle during life as well as after death.* The fact then, that in somatic death and up to the time of molecular death, in which all vital operations finally cease and rigor mortis sets in, the muscles still respond to electricity, is a proof that nerve-force is present and operative in the nerve trunks or in their intra-muscular ramifications.

25. We do not quote as a proof of the existence and activity of nerve-force, the well-authenticated facts as to "the persistence of vital changes in various organs and tissues of the body after the death of the body at large, as is manifested in the performance of ciliary and of muscular movements, in acts of secretion and perhaps even of nutrition, in the maintenance of the local circulation and in the generation of animal heat," or the still more remarkable fact of "the re-union (even after the lapse of some hours) of parts that have been entirely severed, such as fingers or toes, noses or ears, by adhesion between the cut surfaces when brought into apposition which could not take place if the severed parts were dead."‖ Though "so intimate is the relationship, and so obvious is the influence which nervous agency exerts over the operations of nutrition, secretion, &c., especially in the higher animals, that many physiologists have regarded them as essentially *dependent* upon it." But Dr. Carpenter is of opinion that "for this assumption there is

*Dr. Carpenter's Human Physiology, pp. 672, 674. †Ibid, p. 327. ‡Ibid, p. 1055.
‖Dr. Carpenter's Human Physiology, pp. 237, 1055.

no valid evidence; and the whole tendency of recent discovery has been to establish the doctrine of the *essential independence* of the vital endowments of each integral part of the fabric."* We cannot, therefore, regard the remarkable phenomena above mentioned, so far as secretion and ordinary nutrition are concerned, as proof of nervous activity after somatic death, though, as we have just seen, the presumption in favor of that view is so strong as to have led physiologists to that conclusion.

26. But there are conditions of the body, or of its parts, after somatic and prior to molecular death, which prove the persistence of nervous vitality in the former state. Thus the toe or ear, severed for several hours from the body, must be somatically though not molecularly dead. And we are assured by our highest authority that "it is quite certain that after an apparent cessation of all the vital functions,"—which is somatic death—"recovery has spontaneously taken place."† So that under even these extreme conditions nerve-force is not extinct, or resuscitation would be impossible.

Here is a physiological experiment which will illustrate the persistence of nerve-force under the most unfavorable conditions. "The injection of blood into the carotid of an animal recently *dead* by hœmorrhage, and in whom *reflex action had ceased*, is speedily followed by a return of that faculty of the cord, even after its separation."‡ That nerve-force is necessarily present, and muscular contractile power also, wherever reflex actions occur, is too obvious to require proof or to be called in question.

27. Now if nerve-force be thus present after the general death of the body,—that is in somatic and before molecular death,—it ought, *a fortiori*, to be admittedly present in syncope of a temporary duration. But admitting that nerve-force is really present in these states, is there any reason to suppose that it is active to such a degree as to overbalance muscular contractility and produce relaxation?

28. It must be remembered that the condition of "shock" is not uniformly or necessarily attended by simple relaxation or flaccidity of the muscles; clonic spasms or convulsions are not unfrequently present.‖ Thus, it will be within the experience of most persons who have hunted the smaller animals, that a moderate blow on the head will throw them into convulsions, while a severer one, which stretches them out as if dead is attended by relaxation.

29. There is a remarkable fact, comparatively little noticed, which may have a very important bearing on the state we are considering. It is, that certain parts of the brain exercise an inhibitory power over the reflex activities of the spinal cord, which "more readily occur and are much more vigorous and complete in the

*Ibid, p. 350. †Ibid, pp. 1057-8. ‡Dr. Carpenter's Human Physiology, p. 675, by the editor, Dr. F. G. Smith, who refers to the Phil. Med. Exam., N. S., Vol. 8, p. 482. ‖Erichsen's Surgery, p. 275. Surgeon-Major Porter's Surgeon's Pocket Book, pp. 152-3.

absence than in the presence of the brain. The brain must, therefore, in some way or other prevent reflex actions."* Now, if we suppose that the slighter blow, referred to above, only partially arrests the inhibitory action of the brain over the spinal cord, producing so near a balance of the relative powers of the spinal motor nerves and muscles that as one or the other gains the mastery during the nervous commotion, we have clonic convulsions, this part of the phenomena would be intelligently explained. In the case of the heavier blow we might infer that the inhibitory power of the brain over the spinal centres is annihilated, and, as a consequence, the latter, availing themselves of their freedom for "much more vigorous and complete" action, so intensify motor nervous activity as to overpower the contractile tendency of the muscles and hold them inactive and relaxed so long as the then present relations of the brain continue, that is until the latter recovers its full innervation. Surely this is a more reasonable view of the phenomena than to suppose, in accordance with the popular theory, that where convulsions attend this state there is an extraordinary development, or "an explosive disturbance of nerve-force in the cranial centres;" for either of which the circumstances seem specially unfavorable.

30. If the popular theory be the true one, then in certain forms of shock we have nerve-force exhibiting itself with unwonted activity. Can the advocates of that theory then deny that in the more common forms of syncope nerve-force is not also active. We think that taking all the facts into consideration there is reason to believe such to be the case, and that it is even able to control the contractile power of the muscles sufficiently to produce relaxation or flaccidity. The co-ordinate power, however, is wanting, as is seen in the irregular and aimless character of the muscular contractions when these are present.

31. But what of the flaccidity where the spinal cord is itself destroyed by the process known as "pithing?" There is this to say of the effects of this destructive operation, that while paralysis of the spinal centres would at once result, the irritation thus occasioned to the motor nerves at their exit from the spinal canal would be such as for a time to maintain an exaggerated condition of their molecular force, *producing at their periphery an effect very similar to that produced by an increase of ordinary nerve-force.* That such is really the case, and that section or injury of portions of the nervous tissue is so interpreted by experimental physiologists, examples are numerous. Goltz thus interprets the effects of section of the cervical sympathetic in the neck as an irritation rather than as paralysis of the nerves which control the cranial circulation, and refers to these nerves as

*Dr. M. Foster, Hand-book for the Physiological Laboratory, p. 418. Dr. Carpenter's Human Physiology, pp. 671, 675.

vaso-*dilators.** Dr. Brown-Sequard repeatedly refers to mechanical injury of nervous centres producing muscular spasms, which, in turn, he attributes (as we believe erroneously) to increased nervous action.† But from Drs. Todd and Bowman we select examples still more to the point. "By division [of the spinal cord] the whole organ was thrown into an excited state both above and below the section, and therefore manifested phenomena *similar to those excited by volition.* Indeed, we have seen the sphincter repeatedly contracting after division of the cord, without the application of any new stimulus to it; and the dog continuing to raise and depress his tail *as long as the irritation of the cord produced by the section has continued.*" Again, "When an animal is pithed he falls down apparently senseless, and exhibiting only *such convulsive movements as may be due to the irritation of the medulla by the section,* or such reflex actions as may be excited by the application of a stimulus to some part of the trunk."‡

32. The last quotation proves that spasm or convulsion, as well as flaccidity, may attend destruction of the spinal cord. Both quotations prove that the peripheral effects we have attributed to the operation are justified by the practice of physiological authorities. Of course, when the temporary effect of the irritation of the torn and abraded nerves at their origin in the spinal canal subsides, the peripheral effect on the muscles ceases with it. Nor would the nervous excitation referred to, while it lasts, appear to be able at most to effect more than a mere passive restraint on the muscles, (when spasms occur it is effecting less); for the destruction of the spinal centres of the phrenic and intercostal nerves brings the functions of these nerves to an end, resulting in the cessation of the action of the diaphragm and intercostal muscles; and the animal dies from suffocation owing to failure of respiration.‖

33. These considerations, we think, point strongly to the conclusion already hinted at, that in states of unconsciousness, syncope and somatic death (prior to molecular death) nerve-force is present and active, though for obvious reasons, neither to the mind of the individual nor in the appearances presented to the spectator, is the fact apparent.

The presence and activity of nerve-force is inconsistent with muscular relaxation, on the accepted theory; for on that theory nerve-force is a "stimulus" to muscular contraction and this is absent. But taken in connection with what we have to advance in the next chapter, as to the restraining influence of nerve-force over muscle, the facts of relaxation, and the other facts enumerated above, accord well with our theory.

*Article in Canada Lancet, May, 1877, p. 273; copied from London Lancet, and originally from the then current number of the Brit. and For. Med. Chirur. Review. See also future chapter on vaso-motor innervation, § 199, 210. †Lectures on Central Nerv. Syst., pp. 188, 192, 194. ‡Patholog. Anatomy, pp. 303-4. ‖ Dr. Dalton's Physiology, pp. 441-2.

34. It will be seen, we trust, that in the foregoing observations we have not indulged in mere speculation; but have followed a series of authentic facts, to what appears their legitimate conclusion. While the acceptance of this conclusion is so far favorable to our theory, its rejection does not in the least invalidate it; for if we are unable to account for the relaxation of muscle, in shock or syncope, our friends the physiologists are equally unfortunate; and if one hypothesis can survive this negative result, so can the other, especially as it has been so authoritatively shown from Drs. Todd and Bowman that the fact of relaxation, in the conditions mentioned, does not militate against us.

35. *The relaxation of anæsthesia.*—We cannot close these remarks without a few words on the relaxation produced by chloroform and æther. As is well known, relaxation only occurs here as anæsthesia becomes complete. It is very frequently preceded by muscular rigidity. In the administration of chloroform there are undoubted signs of stimulation in the first stage of the process, but in the subsequent stages the evidence as undoubtedly points to paralysis. That the paralysis is of the cranial, rather than of the spinal centres, is shown by the fact that those functional activities which one after another succumb, have all their centre in the brain, and that none of the phenomena can be referred directly to the spinal cord. The first evidence we find of cranial paralysis is that of mental incoherence, foolish talking, &c., which occurs in the next step beyond stimulation proper, and is an evidence of paralysis of the cerebrum, not unlike the similar state induced by alcoholic inebriation.* As the process deepens, the ganglia which regulate motor automatic power become paralyzed, leaving to the muscles a temporary "balance of power," and these, in part released from ordinary nervous control, usually pass into a state of greater or less rigidity. The subsequent loss of motor power, as well as of the muscular sense and power of co-ordination, are due to the extension of the same paralyzing influence to the cerebellum.

36. Meantime the optic lobes, in which resides the cranial inhibitory power over the reflex activity of the spinal cord,† (referred to above) have ceased to exert this function, and the independent motor power of the spinal cord is free to exert its "much more vigorous and complete control" over the muscular system; and its unnoticed power is seen in the relaxation of the muscular tissues which supervenes as the foregoing stages become complete in full anæsthesia. The medulla oblongata is the last of the cranial ganglia to succumb. When it does, respiration ceases; blood stasis occurs, accelerated by paralysis of the sympathetic system and of the inherent organic ganglia of the heart.

37. It has been customary to refer to the early occurrence of

*Dr. Anstie, Stim. and Narcot., pp. 172-3. †Dr. M. Foster, Hand-book for the Phys. Labor., p. 418.

sensory paralysis, as beginning at the extremities; but it may well be questioned whether anæsthesia consists in preventing the sensation of pain from traversing the nerves. It is more probable that messages of pain really reach the brain, but are there unfelt, owing to paralysis of those ganglia whose function it is to awaken the perception of them in the mind: because motor power, which originates in the brain, and sensation, which is peripheral at its starting point, fail together.* It is true that some narcotics paralyze motor power, leaving the intellect clear almost to the fatal end; but this is only another way of stating that while the ganglia are earlier paralyzed by some drugs, the cerebrum escapes their influence for a longer time.

Here, then, as in normal repose, it would appear that "the spinal system never sleeps," but, like a faithful sentinel, only yields its functions when molecular, following somatic death, puts an end to all vital activities; and muscle finally triumphs in the rigidity of death.

38. This is not all in accordance with orthodox ideas on this subject; but a great deal of orthodox nonsense appears in print, as, for instance, the assertion that among the causes of death from chloroform is "excessive irritation of the sympathetic nervous system;" that the vagus is "stimulated by asphyxiated blood;" and again that "in every case of death from chloroform the cause of the death is excitation, either of the motor or of the controlling mechanism of the heart."† For an adverse criticism of these views of Dr. Richardson, by Dr. A. Ernest Sanson, see the article in Braithwaite following the one referred to, from Med. Times and Gazette, July, 1870, p. 107.

39. The truth of the view taken above, that it is the brain that is paralyzed and not the spinal cord, is shown by the fact that all the objective phenomena may be fully accounted for by paralysis of the brain and its ganglia, without any reference to the cord; and by the additional fact that in threatened death from chloroform none of the usual means of resuscitation,—not even attempted artificial respiration,—can compare in success with flushing the brain with blood, by Nelaton's plan of inverting the patient.‡ It is in the brain that the chief paralysis has occurred, (so far as the cerebro-spinal system is concerned) and it is to the restoration of function here that recuperative efforts should be directed.

Dr. M. Hall was right, after all, in attributing the *tone* of the muscles to the influence of the spinal cord, but not in the way he intended, not by a stimulus, but by *a gentle restraint upon muscular contractility, which, when exaggerated, leads to muscular relaxation.*

*Dr. Anstie, Ibid, p. 305. †Dr. B. W. Richardson, Braith. Retros., Jan'y, 1871, pp. 245, 250, 253, from Med. Times and Gazette, 1870, pp. 85, 574. ‡Dr. Bradley, Braith. Retros., Jan'y, 1876, p. 249, from the British Medical Journal, June, 1875, p. 772.

40. *Rigor Mortis.*—This remarkable condition of the muscles occurs in the interval between molecular death and the setting in of putrefaction. When it commences the muscles have lost their "irritability;" that is to say, no further paralysis of their nerves—as by electricity—will cause them to contract. When it occurs there can no longer be a doubt that death is real and vitality extinct.

41. The onset of rigor mortis is not usually delayed longer than seven hours. Its general duration is from twenty-four to thirty-six hours; but it may be longer in appearing and it may pass off sooner, or be protracted through several days. It usually first affects the neck and lower jaw, but sometimes the lower extremities. When established, "all the muscles are affected alike, but the flexors are usually more *contracted* than the extensors, so that the fingers are flexed on the palm and the fore-arm on the arm; and the lower jaw, if previously drooping, is commonly drawn firmly against the upper. It is remarkable that it is equally intense in muscles which have been paralyzed by hemiplegia, provided that no considerable change has taken place in their nutrition. When very strong it *renders the muscles prominent, as in voluntary contraction.*"*

That the muscles are *really contracted* appears from the foregoing, as well as from the statements of other physiologists. Thus Drs. Todd and Bowman say: "The rigor mortis, or stiffening of the body after death, is due to the contraction of the muscles."† Dr. Anstie says, "It is notorious that the most steady and persistent contraction which muscle can possibly exhibit is that which sets in after death, which does not occur till the last remnants of vitality have disappeared, and which, once having commenced, never relaxes till putrefaction releases the tissue from the ordinary laws of molecular attraction."‡ Not only are the voluntary muscles contracted, but the involuntary muscles also. The muscular walls of the several cavities *contract firmly* upon their contents. The same occurs in the arterial tubes to a remarkable extent; while Prof. Valentine has shown that the muscular walls of the intestines are no exception to the rule; and even after separation from the body, portions of intestine exhibit so marked a contractile power as to cause the water with which they have been filled to rise in a few hours to a considerable height in a glass tube connected with one end of the separated portion.‖

42. Rigor mortis may set in immediately after death, as in some cases of asphyxia, and in apoplexy, from chronic softening of the brain or spinal cord: also in poisoning by strychnine, and in cases where strong currents of electricity have been applied before or after death. Also in animals hunted to death, in typhus, and generally in death from slow and wasting disease, occasioning a great general depression of the vital powers; or in more acute diseases which

*Dr. Carpenter's Human Physiology, p. 332. †Physiol. Anat., p. 179.
‡Stim. and Narcot., p. 70. ‖Dr. Carpenter's Human Physiology, p. 334.

powerfully affect the general vital energy, even though only of short duration, rigor mortis occurs early.*

Assuming the foregoing opinions of the physiologists to be correct, these facts support our theory, for in all these instances nerve-force may be presumed to be at a low ebb; and when somatic death occurs, muscular contractile force soon finds itself unopposed and displays its power accordingly. In these cases putrefaction follows with corresponding rapidity.

"On the other hand, when the general energy has been retained up to a short period before death, the rigidity is much later in coming on and lasts longer: this happens, for example, in many cases of asphyxia and poisoning, in which it has been said not to occur at all."† Here nerve-force may fairly be presumed to be capable of dominating the muscle for a longer time after somatic and before molecular death, which, as we have already seen, is sometimes long postponed. That the rigidity, when it once occurred, should be protracted, is what might be expected in a previously well nourished muscle left to itself, in which contractile power has remained unimpaired till death supervened.

43. It has been attempted to explain the occurrence of rigor mortis by attributing it to a lowering of the temperature of the body: "but with this it does not seem to have any relation, since it has been frequently observed to commence long before the heat has entirely departed from the body, and appears first upon the trunk, which is the region last deserted by warmth."‡

44. Dr. Carpenter further says, "Another attempt has been made to show a correspondence between the rigor mortis and the coagulation of the blood in the vessels; and there is certainly evidence enough to make it appear that some analogy exists between these two actions, though they are far from being identical. After those forms of death in which the blood does not coagulate, or coagulates feebly, the rigidity commonly manifests itself least; but this is by no means an invariable rule."‖ It will be seen from this how unsatisfactory this "attempt" at explanation of the phenomena in question is deemed by this distinguished author.

45. At the time the hypothesis we are noticing was set on foot, it was generally believed that there was a close similarity in composition between fibrin and muscular tissue, that the former served as a pabulum for the latter, or, as it is expressed by one author, that "fibrin in a coagulated state forms almost the whole bulk of the muscles."§ Dr. Carpenter, who with other physiologists seems to have entertained similar opinions at a former period, shows that this view is quite untenable, and indeed, that "the evidence is precisely the other way."¶

*Ibid, pp. 333-4. †Ibid, p. 334. ‡Dr. Carpenter's Physiol., p. 332.
‖Ibid. §Wilson's Anatomy, p. 35. ¶Human Physiology, p. 201.

46. It may be shown also that the normal proportion of fibrin, compared with the whole mass of the blood, is so small that it is impossible it can be the cause of the contraction in question. Thus the fibrin is scarcely the one-hundredth part of the *solid* constituents of the blood; and the latter, in turn, constitute only about one-fourth of its whole bulk: so that the fibrin is normally about one-four-hundredth part of the blood as a whole. Estimating the quantity of blood in the human body weighing 144 lbs., at 16 or 18 lbs.,* would give about one grain of fibrin for each muscle of the body; an amount, which, though sufficient for the coagulation in the blood, is surely quite inadequate to produce the phenomenon of rigor mortis in muscle. But even this small proportion of fibrin would not be available for action in the muscles, since the contraction of the entire arterial system, the ducts of the absorbents and the hollow walls of the stomach and intestines have to be provided for. Besides, the normal quantity of fibrin is greatly diminished, and apart from this, its power of coagulation is materially lessened in certain diseases, notably so in typhus,† in which rigor mortis often sets in with great promptitude, the limbs sometimes stiffening in from fifteen to twenty minutes after death.‡ In cholera, too, the blood often contains so little fibrin that it will scarcely coagulate, if in some cases it does so at all; and yet here rigor mortis may be said, in general, to be simply a continuation of the cramps and contractions occurring during life.‖ These facts seem completely to disprove the hypothesis that rigor mortis is the effect of coagulation of the blood; and, indeed, this hypothesis is now quite abandoned in favor of the one to be next noticed.

46. It is proper to remark that fibrin is no longer believed to exist in the circulating fluid *as fibrin;* but that it is formed in the process of coagulation, by the combination of two albuminous substances, which are closely allied as regards their chemical character, both of which are found in the plasma, or liquor sanguinis.§

47. Dr. Brunton attributes rigor mortis to the coagulation of the *plasma of the muscles*, a fluid which "resembles the plasma of the blood, in possessing the power of coagulating spontaneously and separating into a clot and serum. To this clot, corresponding to the fibrin of the blood, the name myosin has been given." He further states that "muscle plasma is somewhat troublesome to obtain, as it coagulates too quickly in the muscles of warm-blooded animals to allow of its preparation from them; and the muscles of frogs, in which it coagulates more slowly, are not always to be had in sufficient quantity."¶

Now, if this muscular fluid, in coagulating produces rigor mortis, this act of coagulation should be co-incident with the setting in of the rigidity. The above quotation asserts that the myosin coagu-

*Hum. Physiol., p. 156. †Ibid, p. 187. ‡Ibid, p. 334. ‖Wood's Prac., Vol. 1, p. 717. §Dr. L. Brunton, Handbook for the Phys. Laborat., pp. 179, 183. ¶Ibid, 449.

lates too quickly to enable it to be procured, but rigor mortis is often delayed for several hours. Here is a discrepancy which augurs badly for this hypothesis.

48. Prof. Kuss, of Strasbourg, in his Lectures on Physiology, adopts the same view of the cause of rigor mortis. He says, "The rigidity in question is owing to the coagulation of the albuminous substance of the muscle (myosin) *by the acids which it has formed.*"* Or, as he says elsewhere, it is "brought on by the acidity of the muscle, and is opposed by its alkalinity."† This has reference to the fact that when muscles are in a state of repose their plastic fluid has an alkaline reaction; but after exercise or strong spasmodic contraction, and during fatigue, the reaction "becomes less and less alkaline and at length is completely acid." But before and after death from ordinary causes, the muscles are in a state of repose, and consequently their proper fluid must be presumed to be alkaline. Active exercise would convert this alkaline plasma into an acid one, but muscular activity under the circumstances is impossible. The acidity is owing to increased activity of chemical changes, a process of combustion, in short, wherein oxygen is absorbed and carbonic acid evolved. This process is going on to some extent in healthy muscles, both when at rest and in action. But it is only in the latter case during severe muscular labor that combustion is sufficiently active for the formation of acid in the muscular fluid.‡ If acid then be necessary to coagulate the muscular fluid, and is itself the effect of active muscular exercise, how is it produced in the muscles of a dead body? It cannot be the result of muscular activity during the closing days or hours of life; nor can it be the result of any muscular action after somatic death. When, then, the muscles finally pass into molecular death, and with this rigor mortis sets in, whence comes the acidity of the muscle plasma? And further, if such acidity be *the effect*, or product, of active muscular contraction during life, how does it come to be *the cause*, or inciting agent, to muscular contraction after death? For, during syncope, when all muscular contraction ceases, the process of combustion is at an end and the formation of acid in the muscle is necessarily arrested, as Prof. Kuss proves by the blood being no longer rendered black or venous, as is the case while combustion is going on, but, on the contrary, it presents nearly all the distinguishing features of arterial blood.‖ If the interchange of elements between the blood and the muscle be arrested in syncope, there are still stronger reasons why death should terminate the process. Whence then the chemical change necessary to produce acidity? And yet it appears certain that the muscle plasma becomes acid after molecular death (that is in the contraction of rigor mortis) as well as after contraction during life; and that it remains acid until putrefactive changes

*Prof. Kuss, Lectures on Physiology, p. 83. †Ibid, p. 71.‡ Ibid, p. 77. ‖Ibid, p. 77.

occur, when it becomes once more alkaline, owing to the ammonia evolved in the process of decomposition.*

Dr. Brunton says, "*Muscle, in dying, on entering into rigor mortis, becomes distinctly acid.*"† Query? Is not the acid reaction the result of the contraction of rigor mortis, just as it is the result of muscular contraction during life, and not its cause?

49. From these considerations we think it will be obvious that the attempted explanation of rigor mortis by attributing it "to the coagulation of the albuminous substance of the muscle (myosin) by the acids which it has formed," as quoted above from Prof. Kuss, is a hypothesis quite untenable. But may not coagulation of the myosin occur otherwise than through acidity, and thus give rise to contraction of the muscle? Prof Kuss says, that "mineral acids, heat at 50°C. (122° Fah.) or anything in short which coagulates the myosin, either hastens or produces this rigidity."‡ This is doubtless true as to results, but admits of a very different explanation. Mineral acids, or a temperature of 122° Fah., may well be presumed effectually to interrupt molecular nerve action, (either in the nerve trunks or their intra-muscular ramifications, or in that secret arena where nerve and muscle come into intimate association;) and thus by cutting off nervous restraint, leave the muscle to its own inherent contractility. This is what electricity does, and it has proved itself a powerful agent in hastening the onset of rigor mortis. We cannot, therefore, admit that this part of the explanation has any more force than the former.

50. Prof. Kuss further remarks that "an injection of serum or of alkaline liquid entirely prevents or delays" the setting in of cadaveric rigidity. This is true also, but it is not necessary that the injected fluid be alkaline, for he himself tells us that injecting hot water (experiment of Brown-Sequard) produces a similar effect,‖ doubtless by assisting in maintaining for a time the existing polarity of nerve-force, and so prolonging its domination over the muscle, thus delaying molecular death. The injection of a mixture of alcohol and carbolic acid (both of which coagulate albumen), for embalming purposes, relaxes cadaveric rigidity after it has set in.§ But here (when rigor mortis has occurred), life is wholly extinct, molecular death has occurred, all vital operations are at an end, and the physical power of contractility alone remains in the muscle. The muscle is amenable, not to the laws of vitality, but to those of matter; the modification of its condition from a state of contractility to one of relaxation, by the injection into its substance of the fluids mentioned, is purely a physical act, and when these have expended their influence it will return to its former contraction, until other physical forces disintegrate it in the process of putrefaction.

*Prof. Kuss, Lectures on Physiology, p. 83. †Hand-book, &c., p. 362. ‡Prof. Kuss, Lectures on Physiology, p. 83. ‖Ibid, p. 71. §Dr. Carrick, Braith. Retros., July, 1871, p. 270.

The fact, then, that during merely somatic death, ere nerve-force has ceased to act, the injection into the arteries of warm water defibrinated blood, or other fluid, not necessarily alkaline, postpones the occurrence of molecular death, and with this the setting in of final rigidity, does not prove that the myosin is at all concerned in the process: the delay in question being equally well accounted for by the prolongation of the existing relations of molecular polarity between nerve and muscle.

51. Here we are fortunately in accord with the older living physiologists, and before it is admitted that they were in error in attributing rigor mortis to muscular contraction, it must be conclusively shown:—

1st. That the coagulation of muscle plasma and the setting in of rigor mortis attend each other as cause and effect, and that the former is invariably present as an essential condition of the occurrence of the latter.

2nd. If the development of acidity in the muscle be due to muscular contraction, and its presence be necessary to the coagulation of muscle plasma; and this coagulation, in turn, be an essential condition for the occurrence of rigor mortis, whence comes the acidity after death, and during the repose of the muscles, of which the necessary contraction, as the first link in the series, is wanting?

3rd. Why should acidity of the muscles *follow* muscular contraction during life (as an effect), and *precede* it (as its cause) after death?

4th. Why is muscular plasma so copious, or so active, as to cause almost immediate rigidity after death from certain exhausting diseases, (and after the application of electricity), and yet permit rigidity to be much longer deferred when the muscular system has been previously well nourished, almost until the hour of death?

5th. According to Dr. Lionel Beale, fibrin is non-living matter,* and is the product of the death of albuminoid bioplasm. If this be true of fibrin, it is very likely to be true also of myosin, which is said closely to resemble it. Coagulated myosin is dead: and if the muscle also be dead, and its inherent contractile power at an end, in what manner does dead matter, acting upon dead muscle, produce so perfect a counterfeit of muscular contraction, that one of the keenest observers of the day pronounces it "the most steady and persistent contraction which muscle can possibly exhibit?"†

52. Even if these conditions were fulfilled, the hypothesis in question sustained, and the fact established, that rigor mortis depends upon the coagulation of the muscle plasma and not upon post mortem contraction of the muscles, the fact would not affect our theory further than to deprive us of a very striking illustration

*Disease Germs, pp. 136–7. †Dr. Anstie, Stim. and Narcot., p. 70.

of muscular contractile power in the absence of nervous agency, of which numerous other, though less remarkable, examples are not wanting.

53. Such are the principal facts in regard to rigor mortis. If the reader adopts the view that the muscles are really contracted in this state, he will either agree with us that their contraction is the result of their own inherent contractile power, which survives the general life of the body and of the nervous system, or else that the muscles are still acted on by the "stimulus" of nerve-force, which according to the accepted theory is essential to the display of muscular contraction, a view of the case which under the circumstances seems too palpably absurd.

On the other hand, if the myosin hypothesis be regarded with favor, much additional proof will be necessary to justify it, while at present there appears to be much force in the arguments against it. Notwithstanding Professor Kuss's adoption of this theory, we find him saying that "muscular contractility is a purely physical property of elasticity; *the rigidity of a corpse is a phenomenon of the same order as muscular contraction in the living body.*"*

54. *Other post mortem muscular contractions.*—We have already made a brief reference to other post mortem muscular contractions, which are very remarkable in themselves, accord well with our theory, and are deserving of more than a passing notice. These muscular movements have been especially noticed after death from cholera and yellow fever. In some of these cases, the balance of power between nerve and muscle appears to have been so nicely maintained in somatic death, that what is called "mechanical stimulation,"—in reality depression—applied to the muscles themselves, and acting doubtless on their intra-muscular nerves, "gives rise to movements strongly resembling the ordinary actions of the living state." In other cases, these muscular contractions "are frequently spontaneous," and occur without the aid of the so-called "stimulus," shewing them, as Dr. Carpenter admits them, to be "*due to the inherent contractility of the muscles, and not in any degree dependent upon the operation of the nervous system.*" The truth of this conclusion was shown by Dr. Dowler, who "proved experimentally by completely separating limbs which exhibited these movements, from the trunk of the body, that the influence of the nervous system was not in any degree essential to their production."† The following are among other examples of these post mortem muscular movements. "In one case, about ten minutes after the cessation of respiration and circulation, Mr. N. B. Ward saw the eyes open, and move slowly in a downward direction; this was followed in a minute or two subsequently by the movement of the right arm, (previously lying by the side,) across the chest; there was also a slight move-

*Lectures on Physiology, p. 88. †Dr. Carpenter's Human Physiology, pp. 327, 328.

ment of the right leg, and these movements of the limbs (those of the eyes occurring only once) were repeated to a greater or less degree four or five times, and fully half an hour elapsed before they finally ceased. In a case observed by Mr. Helps, the subject of which was a man of remarkable muscular development, the fingers continually twitched and trembled after respiration had ceased, and the fibres of the muscles were in a state of rhythmical motion, so that when the fingers were pressed on the belly of the biceps, a sensation as of the pulsation of an artery was plainly felt; the muscles of the arm *acted forcibly* even on a slight *irritation, (?)* the forearm being powerfully flexed when the biceps was struck with the side of the hand, and the fist being doubled or the hand extended, according as the flexors or extensors on the forearm were irritated in the same manner." In some of the similar cases recorded, contractions of various muscles continued for three or four hours, and then the muscles passed into a state of rigidity.*

55. "Some curious rhythmical movements have been observed by Dr. Brown-Sequard, in the diaphragm, intercostals and some of the muscles of locomotion, both after death and after section of their nerves during life. These movements could not be in any way dependent upon reflex action, because they took place when the muscles were completely cut off from the nervous centres; sometimes to the number of from five to twenty in a minute, and for as long as a quarter of an hour after death; and occasionally recurring in a living animal for many months afterwards, especially when the respiration was impeded and the circulation hurried."†

56. These two classes of muscular contraction can neither be attributed to nervous agency nor to coagulation of plasma of either the blood or muscles; and the only explanation possible for them is that given above by the distinguished author from whom we quote. How natural they seem when looked upon simply as the effect of the gradual relaxation of the restraint of nerve-force over the muscles; exhibiting itself first in one fasciculus, or in one muscle, then in another, until finally the muscles become wholly free, and then pass at once into a state of general rigidity, and so remain until this wonderful property of contractility is ruined in putrefaction!

57. The principle for which we are contending, finds another striking illustration in "the post mortem contractions of the parturient uterus, to such an extent as to expel the fœtus of which the patient had died undelivered; a phenomenon which has been several times recorded:" and in the remarkable case witnessed by Dr. Robert Lee, "in which the patient having died suddenly from the rupture of the uterus and escape of the fœtus into the abdom-

*Dr. Carpenter's Human Physiology, p. 327. †Gazette Medicale, 1849. Note Dr. Carpenter's Human Physiol., p. 319.

inal cavity, the uterus was found, when an examination was made twenty-four hours after death, to be completely inverted."*

In the act of parturition "the contractions of the uterus, which are alone sufficient to expel the fœtus when there is no considerable resistance, are not to be regarded as reflex: and it is only in the co-operation of those associated [voluntary] muscles, which come into play in the second stage of labor, when the head is passing through the os uteri and is engaged in the pelvic cavity, that the assistance of the spinal cord and its nerves is called in."† The same author, writing of parturition, says, again, "In this act, the muscular walls of the uterus are primarily concerned; for a kind of peristaltic contraction takes place in them, the tendency of which is to press the contents of the cavity from the fundus towards the os uteri, and finally to expel them; and this contraction is alone sufficient to empty the uterus when no impediment is presented to the exit of the fœtus, as we see in the occasional occurrence of post mortem parturition. . . There is no proof whatever that these changes are dependent upon nervous influence; in fact, there is much evidence that the parturient action of the uterus is *not* the result, (as some have maintained it to be) of a reflex action of the spinal cord, but *is due to its inherent contractility:* for numerous instances have occurred in which normal parturition has taken place, notwithstanding the destruction of the lower part of the cord, or the existence of complete paraplegia, which marked its functional inactivity; and the continuance of the peristaltic action for some time after somatic death, when neither the cerebro-spinal nor the sympathetic system can afford any supply of nervous power, is yet a more satisfactory proof of the same position."‡

58. Uterine contractions may, however, be excited by reflex action in various ways, and by the influence of certain drugs operating through the nerves supplying that organ, but we shall have reason to see, in future chapters treating of ergot and electricity, that it is rather by withdrawing nerve influence than as a "stimulus," that uterine contractions are thus induced. Meanwhile, the facts recounted above show us in the action of the uterus, a palpable proof of the inherent and independent contractile power of muscular tissue, displaying itself in the entire absence of nervous agency, and surviving even the general life of the body. With such an illustration, from the authentic records of physiology itself, the wonder is, not that the principle we are advocating should be asserted, but that it has not long ago been generally promulgated. For a fuller consideration than has yet been given to the present doctrine of physiologists regarding the "excitability" of muscle, through the agency of so-called "stimulants" to the muscle itself, or its motor nerves, see § 86.

*Dr. Carpenter's Human Physiology, p. 334. †Ibid, p. 696. ‡Ibid, pp. 979, 980.

59. We do not expect, or intend, to exhaust in this chapter the proofs and illustrations of the truth of the principle now asserted; for additional evidence in support of it will be found throughout this entire essay. But, before concluding, it will be well to remark that the general principle here advocated is not invalidated by the fact that certain poisonous gases and narcotic drugs diminish or abolish the response of the muscles to the action of electricity.* This is what physiologists mean when they allude to muscular "irritability" being "deadened" or "destroyed" by the agents in question. When it is considered that muscular fibrillæ average about 1-10,000th of an inch in diameter,† (in some instances as low as 1-20,000th) and that on the integrity of this delicate structure depends its power of contraction, it need excite no surprise that the imbibition of liquids and gases, destructive to all delicate tissues, should so alter the microscopic relations of the ultimate components of the fibres as to impair or destroy this physical property.

60. But there is a further explanation of the fact in question which must not be lost sight of. The narcotics mentioned paralyze the nerve-trunks or the intra-muscular nerves; and this effect, once carried to a certain degree, a relation is established between the nerve and muscle, which the additional paralysis of electricity does not materially alter. In proportion as nerve-force has been extinguished, there will be less of the same kind of action to be produced by electricity, and less effects to follow. If the nerves are entirely paralyzed, electricity will produce no effect at all on the muscles,‡ and in physiological parlance, their "irritability" will be said to be "destroyed."‖ One of these modes of explanation refers to the action of these poisons on the nerves, the other to their action on the muscles. It is quite reasonable to infer that both these tissues suffer from the imbibition of these noxious agents, in which case, a double cause would exist for the loss of "irritability" referred to.

61. Nor are we prepared to yield our ground to the fact that the nutrition of muscular tissue suffers, or is impaired, from causes operating through the nervous system, as from lesions of nervous centres, or from wounds or injuries of nerve trunks, which serve to connect these centres with the periphery. Such impaired nutrition, or atrophy, as is well known, may be the result of mere disuse, (owing to enforced quietude from wound or injury), or it may arise from injury of those nerves, or of those filaments of compound nerves, which preside over the nutritive functions. Thus, "when a nerve is injured, the muscle may be paralyzed [to the will], sensation destroyed, or nutrition attacked. But, for obvious reasons,

*Dr. Carpenter's Human Physiology, p. 320. †Ibid, p. 306. ‡Dr. J. Russell Reynolds, Lec. on Clin. uses of Elec. p. 37. ‖See chapters on Electricity.

these triple results will usually occur in one and the same case, but in differing degrees, as motor, sensory, or nutritive nerve fibres happen to suffer more or less."*

This dependence of the muscular tissues upon the nervous system for their proper nutrition, is quite in accordance with what is known as to the mutual relations existing between the several parts of the living organism; and is quite as consistent with the views of the relations of the motor nerves to the muscles, here advocated, as with the one currently received.

62. It has thus been shown that an active power of contraction is present in muscle, as in the fœtal heart, before the existence of any nervous system or nerves; that in the lower forms of life this property is much more extensive than any corresponding nervous system; and that the facts, as at present established, appear to show that this inherent contractile power displays itself, (as in rigor mortis) after all nervous life is extinct. This being the case, we think our first principle, or proposition, may be claimed to be fairly established.

63. We desire, in concluding this chapter, to invite the reader's attention to the fact that what we here ask him to accept is but a very slight extension of a doctrine freely accepted and taught by most of our leading physiological writers. Indeed, very frequently they seem on the point of admitting all we claim, and appear as if they really intended to do so, and yet stop short on the very brink of the announcement. Here is an example of this, from Dr. Carpenter, who combats the teaching of some physiologists, "that muscles, though not depending on nerves for their peculiar vital power [of contractility] are yet dependent upon them for the exercise of it."† If the "hypothesis" here objected to by Dr. Carpenter be untrue, then the opposite of that proposition must be true, namely, that muscles are neither dependent on nerves for their vital power, nor for the means of exercising it, which is equivalent to saying that they possess an inherent contractile power of their own, independent of nervous agency, and this is precisely what our first general principle, or proposition, asserts.

Taken by itself, the fact of the existence of this endowment in muscular fibre is a most interesting one; but, associated with other facts, bearing upon the relations of the musculo-motor nerves to the muscles, and of the vaso-motor nerves to the muscular fibres of the middle coat of the arteries, it assumes a practical importance in the study of disease and certain kinds of drug action, which deserves attention, and which will be referred to in subsequent chapters.

The closing sentence of this first proposition, asserting the influence of the nervous system in regulating muscular contractile power, for voluntary purposes, is universally admitted and needs no special

* Drs. Mitchell, Morehouse and Keen, Gunshot Wounds, &c., p. 76. †Human Physiology, p. 325.

proof. That this regulating power is a restraining one, however, is not generally admitted, and will be considered in our next proposition.

CHAPTER II.

NERVOUS INFLUENCE RESTRAINS, NOT COMPELS, MUSCULAR CONTRACTION.

64. *Second general principle.*—The influence exerted by the nervous system in its relations with muscular tissue is that of a *restraining* and not that of a compelling power. Nerve-force, then, so far from being the ally, is the direct antagonist of muscular contractile power; and the latter displays itself to the best advantage in proportion as the influence of the former is withdrawn.

65. *A missing link.*—A beautiful illustration of muscular activity in a peculiar form, is to be found in the spiral tendril of the pedicle of the vorticella; while the evidence of "a missing link," in current physiology, is furnished by the account physiologists afford of the force which opposes the avowedly inherent contractile power of that muscular filament.

The vorticella is one of the microscopic infusoria. Its body is generally oval or spindle-shaped. In several species it is furnished with a stem-like appendage, which consists of a transparent sheath, containing a fine thread-like muscle, coiled like a spiral spring. The distal end of this pedicle is usually attached to some fixed object in the water; and when at rest, or dead, the spiral muscle is found closely coiled and the pedicle shortened to the utmost. When the animal is active, the sudden elongation of the spring projects the body forwards, perhaps in search of its prey; and as occasion requires, (as when disturbed), the coil is as suddenly condensed and the body retracted. When fully extended, some species are one-twelfth of an inch in length, but others diminish to one-two-thousand-three-hundredths.*

Professor Rouget, quoted by Professor Kuss, of Strasbourg, in his Lectures on Physiology, in describing the mechanism of the vorticella, says, "It frequently happens, during the life-time of the animal, that the contractile fibril is severed, and thus the continuity between it and the body, or the trophic centre of the whole animal, is broken: in this case, although the sheath is perfect, the body, living and swimming by means of its vibratile cilia, drags at its inferior part the dead contractile fibril, rolled up like a tendril, having forever lost the power of further elongation."†

Whether the loss of this useful organ, as thus described, is the result of disease or injury, or whether at some stage of the develop-

*Pritchard's Infusoria, p. 278. †Prof. Kuss, Lectures on Physiology, p. 89.

ment of the animal the pedicle is shed, or separated by a similar natural process appears not to be certainly known. When in its normal state it is a part of the organism, and is regulated "by external conditions as though the animal were possessed of consciousness or will."*

66. Prof. Rouget has no hesitation in attributing the shortening of the spiral filament to "an inherent property of the living muscular fibre" composing it, which property he regards as "a necessary result of its structure and of its elasticity."† This is quite in accord with the opinions of other physiologists as to the endowments of muscular tissue, already quoted, and is undoubtedly the true explanation.

67. Neither this physiologist, Prof. Kuss, nor any other, seems to perceive that muscular contraction is in this way amply provided for, without the necessity of assuming the existence of an additional power or "stimulus" to its contraction, derived from nerve-force. The excessive provision thus (hypothetically) made to ensure contraction of muscle, is the more noticeable when contrasted with the laborious and even ludicrous attempts to find the power by which this spiral muscle is elongated.

68. Prof. Rouget says, "The lengthening of the fibre is the result of the forced extension of the spring by means of *a movement* connected with the act of nutrition." What that "movement" is, or in what way it elongates the muscle, he does not indicate. Again, we quote, "during life, the tendency to shorten is combated by *an extending cause*, which prevails during the repose of the muscle."‡

Here, then, is an undefined "movement," "an extending cause," and subsequently "a moving cause," put forward to oppose the inherent contractile power of the muscular tissue, and so to elongate the spiral.

Is this physiological science? Why, such an explanation would be laughed out of the lecture room, if made by an obscure individual, like the writer; but coming from distinguished physiological chairs, it is, simply,——indicative that there is "a missing link" here which physiology has not yet supplied.

69. That missing link is to be found in the doctrine that nerve-force is a restraining and not a compelling power towards muscular fibre. Here is the complement to the half-truth which Prof. Rouget acknowledges. Inherent muscular power contracting and shortening the spiral on one hand, and on the other nerve-force inhibiting or arresting that contractile power of the muscle, and so producing relaxation.

70. We cannot, of course, explain the hidden process by which the molecules of the nerve act upon the molecules of the muscular fibre, to counteract muscular contractile power: nor can the physiol-

* Pritchard's Infusoria, p. 586. †Prof. Kuss, Lectures on Physiology, p. 90. ‡Ibid, p. 90-91.

ogist explain how nerve molecules operate so as to "stimulate" the muscle to contract; but one mode of action is as conceivable and as possible as the other.

71. In ordinary muscular repose, the nervous polarity may be assumed to be adjusted so as to dominate the muscle, and secure that degree of relaxation known as muscular tone. A modification of this polarity, whether brought about by the operation of the will, or as the result of mechanical agents or of a paralyzing disease, sets the muscle free, and it passes into a state of contraction accordingly; in the former case, in obedience to volition, and subject to co-ordinative power; in the latter cases, irregularly, as in spasm and convulsion.

72. Such a view of the case, we think, suffices for ordinary muscular contraction. But in the case of this microscopic spiral, there would seem to be a necessity for some *active* power of elongation as well as of contraction. A mere negation of contraction will not suffice, because the animal darts forward with a degree of suddenness, elongating the spiral in doing so. Perhaps this necessity may be met by assuming that while nervous force negatives the contractile power of the spiral muscle, and relaxes it, the action of the vibratile cilia, (which are readily seen moving with extreme velocity) propels the body forward, as we have already seen is the case, when the pedicle is dead or no longer capable of activity.

73. Enough has been said to show that the principle for which we are contending not only loses nothing by comparison with the ordinary physiological theory, but that it presents (as we think) a much more natural and reasonable explanation of the phenomena of muscular contraction and relaxation. The proofs on which this principle is to be sustained and the answer to objections which naturally arise, have now to be entered upon.

74. On the very threshold of this chapter we will be met by the exclamation, "*If this principle or proposition be true, why does not a muscle at once contract when its motor nerves are cut, as in wound or injury?*" This is so important an objection, and we are so little embarrassed by it, that we proceed to answer it at once, before passing to the more positive proofs of the principle asserted. In order to do this, however, it is necessary to consider what is known of nerve-force and its mode of action on muscular fibre cells.

75. "Nerve-force is developed through the agency of cells . . . and is to be regarded as but a peculiar modus operandi of the same [vital] force as that which is elsewhere operative in cell development."*

The special cells which generate nerve-force are those of the vesicular or grey matter of the nervous centres, and the gelatinous fibres of the sympathetic ganglia.†

*Dr. Carpenter's Human Physiology, pp. 132, 350. †Ibid.

The sensitive and motor nervous cords, or trunks, composed of white fibres, do not contain these peculiar cells, or are supplied with them only exceptionally at the peripheral extremities of the sensitive nerves and nerves of special sense.*

76. These tubular nerve cords are, therefore, regarded not as originators, but simply as conductors of nerve-force ; or of the molecular change, in which that force manifests itself.†

77. Of the precise manner in which nerve-force is brought into communication with muscular force nothing certain is known. The following quotation from Drs. Todd and Bowman appears to embody the view of physiologists on the subject:—

"There are no textures which exhibit such proneness to molecular change, under the influence of their proper stimuli, as nerve and muscle. . . . The changes, however, which take place in nerve, when in action, are known to us only by the effects which they produce on the sentient mind or on muscular parts. There is no alteration in the physical appearance of the nerve or its fibres, which can be detected by our aided or unaided vision. Yet from the rapidity with which stimuli applied to nerves produce their effects on distant muscular parts ; from the instantaneous cessation of these effects on the removal of the stimulus, and the speedy renewal of them on its reapplication, we can refer the phenomena to nothing so well as a *molecular change*, rapidly propagated along the course of the nerve from the point of application of the stimulus. And in the instantaneousness of its production, and the velocity of its propagation, we may compare it to that remarkable change in the particles of a piece of soft iron, in virtue of which it acquires the properties of a magnet, so long as it is maintained in a certain relation to a galvanic current these properties being instantaneously communicated when the circuit is completed, and as instantaneously removed when it is broken. *A state of polarity* is induced in the particles of the nerve by the action of the stimulus, which is capable of exciting an analogous change in other particles, whether muscular or nervous ; whence results the peculiar effect of the nerve's influence."‡

78. From this view of the molecular changes which bring nerve and muscle cells *en rapport*, it will be evident, whichever view we take of the action of nerve-force, whether we regard it as compelling muscular contraction or restraining it, we will have to associate in our minds, a certain state of polarity of the molecules with contraction, and an altered or reverse state, with relaxation of the muscular fibres.

79. We will also have, (from the very nature of the case) to attribute to this polarity a certain fixedness or stability, in maintaining its present state until that state be altered by the power of the will; by

*Dr. Carpenter's Hum. Physiology, pp. 132, 342, 879. †Ibid, pp. 335, 349, 351, &c. ‡Physiol. Anat., p. 212.

purely reflex action of the nervous centres; or by some physical agency, such as heat or electricity, &c., acting on it externally.

If this state of polarity were fickle or readily changeable, it would be liable to constantly fail us, perhaps in critical moments, and permit relaxation to occur when contraction was most desirable, and *vice versa.*

80. This state of fixedness or stability of the existing molecular polarity is further shown by the fact that when it is disturbed by agents, such as electricity, it tends to resume its former state immediately on the withdrawal of the disturbing cause. Thus, also, a muscle in a passive state contracts with a sudden spasm when a bullet passes through it, or impinges on or near its motor nerve, but quickly resumes its previous state of relaxation.* Here, no doubt, the molecular polarity between the nerve and muscle cells is disturbed or reversed by the shock; but soon recovers itself and reclaims its power of restraint over the muscular fibres, which it had temporarily relinquished.

From these considerations it will be evident, we think, that while the polarity of the molecules seems easily—because naturally—reversed by an impulse from the nervous centres, a comparatively powerful influence is necessary to effect this change when operating outside of the nervous circle.

81. And now for the application of this. Suppose the muscle to be in a state of relaxation, *(i. e.)* of non-contraction, as when ordinarily at rest. *That state will be maintained so long as the necessary molecular change required to bring about contraction does not take place in the proximate nerve fibres.*

82. When the central ganglia, either acted on by the will, or by impressions received through the afferent nerves, invoke muscular contraction, the necessary molecular change traverses the whole course of the nerve, and at the point of contact with the muscular fibre cells, effects the necessary polar change, and muscular contraction follows.

But suppose the motor nerve trunk to be cut across, the molecular change will be interrupted at the point of section, and will be unable to pass further. As a consequence, the distal portion of the nerve, that with which the muscle is associated, receives no impression. Its molecules are undisturbed. No change has been induced in their polarity. The conditions necessary to a reversal in the state of the muscular fibre have not been brought about, and in the absence of this necessary change in the molecular polarity of the nerve, the muscle does not, and cannot contract. It is paralyzed to the will, indeed, but only because the mandate of the will has failed to reach it: otherwise the muscle is no more paralyzed than at any former time; it is only awaiting the necessary re-adjustment of molecular arrangements, to pass into the state of contraction.

*Drs. Mitchell, Morehouse and Keen, Gunshot Wounds, &c., p. 123.

If it have to wait too long for these conditions, that is, if the wound or injury of the nerve be a serious one, and its repair be long deferred, degenerative changes occur, both in the distal portion of the cut nerve* and in the muscles; and these changes, sooner or later, so modify the relations of polarity between the nerve cells and the muscular fibre cells, that the latter cease to be restrained, and, as we know, pass into a state of contraction more or less permanent.

83. As to the action of electricity on the distal portion of the cut nerve, in inducing muscular contraction,† it is only necessary to remark here that there is no reason to infer that electricity does so by taking the place of nerve-force: and that it is quite justifiable to assume that it acts by temporarily disturbing the existing molecular polarity, and that during this disturbance the muscular fibres pass from restraint and assume a momentary contraction. On the withdrawal of the disturbing force, the disturbed polarity resumes its former state and its former control.

It is by the effects thus produced on muscle, as we shall prove by and by, the good effects of electricity result, by indirectly improving nutrition, and not from any "vitalizing" quality of its action.

When the normal molecular polarity is permanently overthrown, the physical forces (including electricity) are impotent to re-adjust it, so as to restore its proper relations to muscular fibre, which can only be brought about, if at all, through the influence of the central nervous organs. For it is fully established, that after wound or injury of a nerve, where voluntary power over a muscle has been lost, voluntary power is sometimes restored before electricity has any effect in inducing contraction.‡

84. In addition to this, however, we have to invite the reader's attention to what was said in a previous page, (§ 31,) as to the ordinary interpretation put by physiologists on the effects of section or injury of a nervous centre, or of a nervous cord, in continuing the transmission to the periphery, of nerve-force, in a manner not unlike that propagated by an excitation of a nervous centre. The quotations then made from the authorities apply here with equal force, and account for the nerve continuing to exert a restraining influence over the muscle so long as the irritation of the section or injury continues.

85. Another reason (but of less weight and importance) why muscles do not at once pass into a state of contraction, on section of their motor nerves, is found in the fact that most muscles are functionally opposed by other muscles, as in the case of flexors and extensors: when the muscle of one group contracts its antagonist must lengthen, and to this, its passive contraction offers a certain

* Dr. Lincoln's Electro-Therapeutics, p. 73. † Ibid, p. 71. ‡ Drs. Mitchell, Morehouse and Keen, Gunshot Wounds, &c., pp. 137, 141.

amount of resistance, as does also the elasticity of other tissues associated with it.*

Such is our response to this anticipated objection, which from its importance has necessitated a rather lengthy reply, which we trust will be satisfactory to the intelligent reader.

As reference is frequently made in these pages to the present doctrine of a "stimulus" exerted by nerve-force upon muscular tissue, perhaps we ought to consider that doctrine more fully than has already been done. A recent physiological writer† thus asserts it:—

"To explain the functions of nerve tissue, it is necessary to begin by explaining what physiologists mean by the term "excitability." Suppose that a muscle has been cut from the body of a freshly killed animal; so long as it is not interfered with in any way, so long it will remain quite passive. But every time a stimulus is applied to it, either by means of a pinch, a burn, an electric shock, or a chemical irritant, the muscle will give a single contraction in response to every stimulation. And it is this readiness of organic tissues to respond to a suitable stimulus that physiologists designate by the term 'excitability'."

"Nerves, no less than muscles, present the property of being excitable. If together with the excised muscle, there has been removed from the animal's body an attached nerve, every time any part of the nerve is stimulated the attached muscle will contract as before."

Now, the reality of the pinch, burn, or shock is here undoubted; and the contraction of the muscle, as a result, is equally demonstrated. But that the pinch, burn, or shock *acts as a stimulus* is purely hypothetical. This is simply a mode of interpreting the fact, and must not be held to be a fact itself, in the absence of proof. It was doubtless found a convenient explanation of the phenomena, and was adopted owing to the exigency of the prevailing theory of the relations of nerve and muscle; and having been long repeated, has at length been accepted as the true explanation. Had the exigency of the theory not required such an interpretation of the phenomena, is it not highly probable that injury inflicted upon a tender nerve cord of delicate structure, by any such means as these mentioned, would have been more naturally regarded as tending to paralyze, rather than to stimulate its purely dynamical activity? The evidence that such is the true action of electricity will be found in the chapters devoted to that subject: and if this, as the chief among the so-called "stimulants" to muscular tissue, is found to be really a paralyzer, the same must be said of the others.

* Drs. Todd and Bowman's Phys. Anat., p. 164. Drs. Mitchell, Morehouse and Keen, Gunshot Wounds, &c., p. 125. †George J. Romanes, Fortnightly Review, October, 1878, p. 509.

In order to conclude all that it is necessary to say on this subject, we must add what follows.

The fasciculi of muscle are composed of bundles of muscular fibres of microscopic minuteness. These fibres, in turn, are made up of fibrillæ averaging 1-10,000th of an inch in diameter, and these, again, are studded with the proper muscle cells.* Nervous ganglionic cells ramify among the fibres; a network of nerves has been traced not only around the fibrillæ, but nerves are found to penetrate the nucleoli of the nuclei of their cells.† We quote these facts to show the intimate association of nerve with muscle, that the latter is, so to speak, filled with the ramifications of the former; and as nervous ganglia are believed to exist in the muscular coats of the capillaries and smaller arteries for regulating their calibre,‡ so the ganglionic cells, noted above, doubtless constitute local magazines of nerve-force for intra-muscular action. If this be true, then the muscle, even when cut off from the body and from the nervous centres, cannot be said to be divorced from nervous influence, which is interlaced with and resists it, until local molecular changes disconnect the link which binds them.

The experiments in question show that nerve-force is not extinct in either the extraneous nerve trunk or in the interior ganglionic cells and ramifications of the nerves within the muscle. (§ 27-30). Many of these are under the direct control of the nerve-trunk; branches of which are distributed to them, and consequently have their control over the cells of the fibrillæ annulled by molecular change transmitted to them when the nerve-trunk is acted on, as also as when the injurious or corrosive application is made directly to themselves.

As an addition to the foregoing remarks, we commend to the reader's attention the following observations from Dr. Thomas Laycock, Professor of Medicine, Psychology, &c., in the University of Edinburgh: "We must not forget . . . . that not only do the tissues themselves undergo normal vital changes independently of nerves or of the nervous system, but also that nerves and nerve fibrils perform their appropriate functions independently of the nervous centres. Nerves are produced anew in organized plasma, and join on to the general trunk in accordance with the order of embryonic development of the nerves from the periphery towards the centre. MM. Phillipeaux and Vulpian made numerous researches which prove that nerves separated wholly from the nerve centres, and completely altered as to nutrition, may become regenerated, although remaining separate, and recover all their vital properties. *Numerous experiments, also, on the nerves of muscles, show that those motor nerve fibrils have their own inherent properties in entire*

* Dr. Carpenter's Human Physiology, p. 306. † Dr. Klien, Handbook for the Physiol. Laborat., p. 97. ‡ Dr. Ott's Action of Medicines, p. 68, with references to Huizniga, Pfluger's Archiv., Vol. 1, p. 207. Bowditch, Boston Med. Jour., July, 1871.

independence of brain, spinal cord or nerve centres, and not only in separate limbs, but in muscles that have been cut from the limbs. . . . in the development of the embryo the nerves are formed independently of the nerve centres, and the arteries appear before and act independently of the heart; so that the evolution of the vascular system, with its accompanying nerves, is not like the branches of a tree from a common trunk, but like that of a river from a number of rills, or like that of the veins. *The function of the central ganglia is to unify trophic changes in tissues*, and the action of the vessels and their accompanying nerves, but these changes and actions can and do go on independently of either heart or nerve centres."*

87. We have now to present certain facts in proof of our proposition; and in doing so we are glad to avail ourselves of the able arguments in support of this doctrine presented by no less an authority than Charles Bland Radcliffe, M. D., Fellow of the Royal College of Physicians, London, Physician to the Westminster Hospital, and to the National Hospital for the Paralyzed and Epileptic. In his "Lectures on Epilepsy, Paralysis, Pain, &c.," while treating of "the part which nervous influence has to play in the process of muscular motion," this eminent writer and physician lays down the following proposition:—

"*There is reason to believe that ordinary muscular contraction is associated with deprivation of nervous influence, and not with a contrary state of things.*"†

Dr. Radcliffe supports this proposition as follows:—"There is no lack of evidence to show that muscular contraction may occur, in its most exaggerated form, under circumstances in which the amount of nervous influence supplied by the nervous centres to the muscles must of necessity be at or near zero. The convulsion of hœmorrhage is a case in point, a case, too, of no doubtful significance. For if it be true, as it undoubtedly is, that the functional activity of an organ is directly proportionate to the activity of the circulation of arterial blood in that organ, and if the function of certain nerve centres be to supply nervous influence to the muscles, then it follows that this supply of nervous influence must be interrupted in the most effectual manner when the whole muscular system is thrown into a state of convulsion by loss of blood."

"And certainly the inference which may be drawn from the occurrence of convulsion during hœmorrhage is confirmed in the fullest manner by certain experiments of Astley Cooper and Drs. Kussmaul and Tenner."

"I tied," says Sir Astley Cooper,‡ "the carotid arteries of a rabbit. Respiration was somewhat quickened and the heart's action increased; but no other effect was produced. In five minutes the vertebral arteries were compressed by the thumb, the trachea being

*Med. Times and Gazette, 1871, pp. 595, 211. Braith. Retros., January, 1872, pp. 58, 62. †Page 95. ‡Guy's Hospital Reports, No. III, 1836.

effectually excluded. Respiration stopped almost directly, convulsive struggles succeeded; the animal lost its consciousness and appeared dead. The pressure was removed and it recovered with a convulsive inspiration. It then lay upon its side, making violent convulsive efforts, breathing laboriously, and with its heart beating rapidly. In two hours it had recovered, but the breathing was still laborious. The vertebrals were compressed a second time; respiration stopped, then succeeded convulsive struggles, loss of motion and apparent death." Similar compression was made for a fifth time, at intervals during the following days, invariably with the same result.

"The tale which is told by this well-known experiment appears to be, that convulsion may co-exist with a state of things which involves interruption in the functional activity of the great cranio-cervical nervous centres; for such interruption must necessarily be brought about by arresting the flow of blood through the cervical arteries. And this tale is also that which is told, in still plainer terms, by Drs. Kussmaul and Tenner in the following experiment:"*

Here the great vessels leading from the heart to the cranial centres are ligatured, in a rabbit, with the immediate effect of loss of consciousness and general and violent convulsions. Upon untying the ligatures and permitting blood to flow again to the brain, the convulsions ceased, consciousness returned, together with voluntary control over the muscles. "This result is one which is only intelligible on the supposition that the convulsion is dependent upon the interruption in the supply of nervous influence which the muscles receive from certain great nerve centres, so long as these centres are kept in a state of functional activity by the continuance of the circulation."†

88. In other words, when nerve-force is in abeyance, convulsion occurs. When nerve-force may be expected to be certainly present, convulsion ceases, or does not occur. The presence of nerve-force and of convulsion are then incompatible. Nerve-force prevents convulsion. How? By restraining the inherent contractile power of the muscles, on the exercise of which convulsion depends, which asserts itself as soon as this restraint is removed. Is not this a natural and legitimate inference from the facts in question?

89. Dr. Radcliffe lays down the following as his next proposition: "*There is reason to believe that muscles do not pass into a state of contraction when they may be supposed to receive a larger supply of nervous influence than usual.*"

Another experiment of Drs. Kussmaul and Tenner is appealed to in proof of this assertion. In the present case it may be supposed that there will be an increased development of nervous influence in

* Pages 95, 97. †Page 98.

the nervous centres of the head and neck, for all the blood in the body is directed to these centres, by so tying the ligatures as to exclude it from the trunk and limbs. "What happens is, paralysis in the parts from which the blood is excluded, paralysis almost everywhere, convulsion nowhere." If, now, by pressure of the fingers upon the arteries leading to the brain, the supply of blood to the great nervous centres of the head and neck is shut off, the result is general convulsion of great violence.

This experiment "supplies a proof which is not to be controverted, that convulsion is not produced when the condition of the circulation would seem to necessitate increased development of nervous influence in the great nervous centres of the head and neck. This it does, as it would seem, without leaving room for any doubt; and in so doing it furnishes a fatal objection to the notion that increased development of nervous influence, arising from 'determination of blood to the head,' is the cause of convulsion."*

90. Again, "*There is reason to believe that the power of muscular contraction is inversely related to the amount of nervous influence supplied to the muscles from the great nervous centres.*"

"Two experiments, both supplied by the untiring research of Dr. Brown-Sequard,† furnish the clearest demonstration of the truth of this statement." . . . . "In the first, certain muscles are seen to contract with greater power when they are cut off from the influence of the brain and medulla oblongata. In the second, certain muscles are seen to be more apt to enter into a state of contraction after they are cut off from the influence of the spinal cord, than they were before they were so cut off. The facts are altogether unintelligible, if the power of muscular contraction is in any way imparted to the muscles by the action of the great nerve centres. The facts are *not* altogether unintelligible if this power be inversely related to the amount of nervous influence supplied to the muscles by these centres. At present, however, all that is necessary is to bear in mind the facts, as facts, and leave them to tell their own story without further comment."‡ Dr. Radcliffe continues:—

91. "*There is reason to believe that 'augmented irritability' does not imply a state of augmented vitality in nerve or muscle.*"

"Some recent experiments by Dr. Harley‖ appear to furnish very good ground for doubting the current belief, that strychnia and brucia favor muscular contraction by augmenting the vitality of some vital property of irritability in nerve or muscle."

"One of these experiments, (one must serve as an example of the rest) consists in removing the hearts of two frogs, and in placing one in a vessel containing simple water, and the other in a vessel containing a very weak solution of strychnia or brucia. This

* Page 100. † Comptes Rendus. Mai. 16, 1847. ‡ Ibid, pp. 100, 102.
‖ Lancet, 7th and 14th June, and 12th July, 1856.

experiment is very simple. The result is one which shows very plainly that the action of strychnia or brucia is not to exalt, but to extinguish the vital properties of the cardiac muscles and nerves, which would seem to contradict altogether the current notion that the spasms arising from the action of these poisons must be looked upon as signs of exalted vitality in some vital property of irritability; for the result is simply this, that the heart which is immersed in plain water is found to go on beating regularly for some time after the heart immersed in the solution of strychnia or brucia has passed into the state of rigor mortis. And if this be so, if the "augmented irritability" arising from the action of strychnia or brucia, be not connected with a state of augmented vitality in nerve or muscle, it is difficult to imagine any other case of "augmented irritability" in which there can be any such connection."*

92. The last proposition which we shall here quote from Dr. Radcliffe is as follows:—

"*It is difficult to believe that nervous influence produces the state of contraction in muscle by playing the part of a stimulus to a vital property of contractility in muscle.*"

"Arguing from the evidence adduced in the preceding paragraphs, this difficulty would seem to be well nigh insuperable; and so far as I know, this evidence is in no sense one-sided."†

93. It has long been the accepted theory that motor nerve-force acts the part of a stimulus, or of a compelling power, in inducing muscular contraction: and that this force is in excess and the functional activity of the nervous centres exalted, in such states of irregular muscular contraction as spasm, tremor and convulsion.

If this were true, how are we to account for the results just enumerated by Dr. Radcliffe, including the well known fact that in death from hœmorrhage, as ordinarily witnessed in the shambles and elsewhere, when the last drops of blood are draining away and the life and power of the organism are being extinguished, muscular spasms of the severest kind occur? Surely these are not the conditions under which to expect an increase of nervous power, discharging itself with unwonted force upon the muscular tissues! as the present physiological theory requires us to believe occurs in epileptic and spasmodic states generally.‡

94. The same remark will apply to spasms and convulsions arising during the course of paralyzing lesions of the brain or spinal cord, or of apoplectic or other effusions affecting the same centres of nerve power, or from sudden arrest of the arterialization of the blood, as by suffocation or strangling: to die of which latter, "is, indeed, to die of convulsion."‖

* Dr. C. B. Radcliffe, Lectures, &c., pp. 102, 103. † Ibid, pp. 103-104. ‡ Dr. H. C. Bastian, Paralysis from Brain Disease, p. 27. Dr. Anstie, Neuralgia, p. 8, and numerous other authorities. ‖ Dr. C. B. Radcliffe, Lectures, &c., p. 91.

Does it need any argument to prove that in these cases, vital or nervous force is not increased, exalted, or unduly active, as we are required to believe it to be, in accordance with the popular theory just mentioned?

95. Dr. Anstie, who has paid special attention to this subject, assures us: "It is a fact that so far from being an evidence of excitement, muscular rigidity under chloroform is one of the regular symptoms of chloroform narcosis with many patients. It is characteristic of the moment when communication between the nervous centres and the muscles is about to be cut off entirely, owing to the temporary death of the nerves."*

In narcotic poisoning, "one fact stands out clearly, that convulsive movements never occur until such a late stage of the narcosis as necessarily implies that the life of the nervous system is greatly impaired. Even in the case of strychnia-poisoning, the apparent increase of common sensibility, which exists beween the spasms, is accompanied with loss of discriminative power in the organs of special sense. And in the case of most narcotics, motor paralysis has already commenced, at any rate in the hind quarters before convulsion in any shape occurs."†

Again, "From the slightest tremors of alcoholic poisoning to the most severe tetanic spasms of acute strychnia-poisoning, there is not a single stage of the descent at which we do not find ourselves confronted with simultaneous evidences of paralysis, which when once looked for cannot be missed. Every variety of irregular and untimely muscular contraction, in narcosis, is connected with the severance of the lines of vital communication."‡

"The most striking of all vital motions, those of the muscular system, may at least be strongly suspected to depend upon the physical properties of the tissue in which they are developed: and *the true action of vital force would appear to be rather that of restraining muscular contraction than of exciting it.*"‖

96. We must not fail to notice here the intimate association often existing between convulsion and paralysis. Dr. H. C. Bastian makes frequent reference to this in his work on "Paralysis from Brain Disease." Thus, hemiplegia is frequently preceded by unilateral convulsions, in which the same muscles which had been previously convulsed were subsequently found paralyzed.§

Andral has explained the fact of convulsions occurring on one side of the body, with hemiplegia on the other side, as indicating lesions in both hemispheres; a grave one in the hemisphere causing the paralysis, and a slighter one in the opposite hemisphere, giving rise to convulsions or spasms in the non-paralyzed side. Dr. Bastian adopts this explanation as decidedly the one "which finds most support from a careful scrutiny of the facts."¶

* Stimulants and Narcotics, p. 81. † Ibid, p. 199. ‡ Ibid, p. 332. ‖ Ibid, p. 70. § Ibid, pp. 26-7, 71. ¶ Ibid, p. 72.

Now, is that a satisfactory theory of these diverse phenomena, which requires us to believe that the hemisphere with the gravest lesion is so incapable of developing nerve-force that the muscles depending upon it are paralyzed; that, in fact, its functional activity in the production of nerve-force is suspended; while the other side of the brain, with a lesion only second in severity, is supposed to be unduly excited and to be generating a larger than usual amount of nervous energy, which is thrown upon the motor centres of the base of the brain, inducing the convulsions referred to?

Is it not much more natural and reasonable to say, that in both sides of the brain the production of nerve-force is diminished; that in the hemisphere with the gravest lesion it is most diminished, and that the resulting paralysis is only a worse stage of the same disease, which in the hemisphere least injured displays itself in a degree less severe?

97. The same remarks apply to unilateral chorea, which is sometimes followed by unilateral paralysis of the same side; and a unilateral paralysis, as it disappears, may in the progress to recovery, manifest the phenomena of unilateral chorea.*

What does this prove? That the spasms and twitches of chorea are from an opposite state of the nervous centres to the hemiplegia; that in the former nerve-force is unduly exaggerated, and in the latter unduly diminished?

No! but that both the chorea and the paralysis are simply but different stages of the same descent. Pass below chorea and you have paralysis. Ascend from paralysis and you pass through the still weakened state of nerve-force which exhibits the choreic stage of the same general depression.

We are glad here to be able to quote so excellent an authority as Dr. Samuel Wilks, of Guy's Hospital, who long since regarded chorea as depending on "a weakened condition of the nervous centres," and as requiring for its cure, "good nourishment and tonic treatment," "a bracing up or restoration of the original nerve-power," &c.† What is here said of chorea is equally applicable to other cases of "insanity of the muscles," characterized by tremors, spasms, or irregular muscular contractions.

As a practical fact, in this connection, we add what follows:— "A very curious variety, as it seems, of choreic convulsion, which is characterized by involuntary movements of a rotary or semi-rotary character, has been treated by Dr. Radcliffe in two remarkable cases, by repeated doses of alcohol, with very complete success, the movements being arrested when a full stimulant effect has been produced."‡

98. Let us briefly consider the conditions under which epileptic convulsions occur. Passing over the vague and variable antecedent

* Dr. Bastian, Ibid, p. 159. † Braith. Retrospect, July, 1869, pp. 64-5.
‡ Dr. Anstie, Stim. and Narcot., p. 127.

sensations, which may or may not be present, what do we find as to the fixed phenomena?

Among the pathological changes tabulated by Dr. Brown-Sequard the first is contraction of the blood vessels of the brain, and as a consequence, the loss of consciousness. With these appear spasmodic contractions, beginning with the eye, face, cervical and thoracic muscles, producing asphyxia, and finally general clonic convulsions of the entire body.*

This contraction of the blood vessels, causing a diminished supply of blood to the brain, occurring, too, as the first of a series of remarkable changes, is worthy of special notice. Besides producing the loss of consciousness, its effects are also seen in the temporary paleness of the face, just preceding the attack. It is not until the spasms are developed, and the return of venous blood from the brain is prevented by the cervical and thoracic spasms, and the arrest of respiration, that the opposite state displays itself in the swollen and purple features and dilated veins.

The opinion of some eminent writers and teachers may be quoted to show that convulsions depend for their proximate cause upon anæmia of the brain.

Dr. Ringer, while recognizing that convulsions may be induced by various causes, regards the conditions of the nervous centres producing the attack as in every instance identical.† Dr. George Johnson, of King's College Hospital, London, "thinks that the action of chloroform inhalation in warding off a threatened fit, and in cutting short a violent and prolonged paroxysm, is *as uniform and certain as the action of anæmia in exciting convulsions.*"‡ Dr. John McNab,‖ writing of puerperal convulsions and the treatment by blood-letting, says: "This method of treatment is evidently based on incorrect views of the pathology of convulsive diseases; for recent observations and experiments prove that neither the proximate nor the remote cause of convulsions is to be found in a hyperæmic condition of the brain. M. Delasiauve, who has paid great attention to the subject of convulsions, pointed out, for the first time, that in the paroxysms the face is at first pale and anæmic, that the attacks are *preceded by signs of a feeble circulation*, and that the congestion is greater as the paroxysm begins to disappear. This observation was subsequently confirmed by Trousseau, Georget, Watson, and other accurate observers; and, besides, the experiments of Kussmaul and Tenner clearly proved that convulsions arise from an anæmic condition of the brain, rather than from arterial or venous congestion." This writer, after combating Solley's congestive theory, adds: "We find in the history of the disease, that convulsions are almost coincident with the stage of depression, and not

* Lectures, Phys. and Path., Central Nervous System, pp. 183-4, 206. Dr. W. Hammond's Diseases of Nervous System, p. 579. † Therapeutics, p. 87. ‡ Naphey's Modern Therapeutics, pp. 39-40. ‖ Edinburgh Medical Journal, 1873, p. 230.

with that of vascular excitement." Having reviewed the arguments in favor of venous congestion as the cause of convulsive movements, he concludes: "Indeed there is nothing in all this evidence, physiological or chemical, to nullify the conclusion already drawn, that venous blood has no special action in producing convulsions. Convulsion is the sign of depressed, and not of exalted vital action."* Drs. Kostle and Niemetshek, of Prague, "consider that the brain in epileptics is always anæmic, and that this condition is invariably found by ophthalmic examinations."† Dr. George Johnson (just referred to) writes as follows: "A number of facts point to the conclusion that both the loss of consciousness and the convulsion of epilepsy are the result of sudden and extreme anæmia of the brain." "Kussmaul and Tenner state (on epileptic convulsions from hœmorrhage, New Sydenham Society, 1859) that in numerous cases of dogs, cats and rabbits they observed, without a single exception, violent and general convulsion preceding death from rapid loss of blood."

"The same observers found that an interruption in the supply of blood to the head of a rabbit by ligature or compression of the arteries produces epileptic fits as surely as hœmorrhage does. In about one hundred rabbits they ligatured or compressed the carotids or subclavians, from which, be it remembered, the vertebrals proceed, and in every instance, except that of one very old, lean and feeble rabbit, convulsions occurred. . . . . The descriptions of the convulsions thus artificially produced in these animals shew that they were essentially the same as epileptic convulsions in the human subject. There was the dilated pupil, the tonic spasm, quickly succeeded by clonic convulsions so violent as to throw the animal forcibly forwards, to a distance of one or two feet, and sometimes even over the shoulders of the experimenter. *These experiments suffice to shew the fallacy of the explanation which Dr. Brown-Sequard and others have given of clonic convulsions in man.* The clonic convulsions, as well as the preceding tonic spasm, must be due to want of blood, and not to the altered quality of blood in the brain."‡

99. The author from whom we quote attributes the whole series of convulsive attacks arising from uræmic poisoning, retained excreta, unwholesome air, undigested food, alcoholism, occurring during the onset of the exanthemata; in pyæmia, from prussic acid, as each and all produced by anæmia of the brain, "resulting from contraction of the cerebral arteries; *the arterial spasm being excited by the presence of morbid blood in the vessels.*"‖ The fact as to the anæmia is beyond doubt, but the mode of explaining its presence must be seriously called in question. In a future chapter it will be shown that arterial

* Braith. Retros., January, 1864, p. 173. † Quoted by Dr. W. A. Hammond, Diseases of Nervous System, p. 571, who disputes this opinion, but offers no facts in refutation of it, or of the facts and experiments which support it. ‡ Braith. Retros., January, 1869, pp. 61-2. ‖ Ibid.

contraction depends on the contractile power of the arterial coats ; which it is the function of the vaso-motor nerves to restrain, and consequently to dilate the vessels. The paralysis of the vaso-motor centres or nerves by "morbid blood" puts an end to this dilating and restraining power, leaves the muscular walls of the arteries free to contract, and a diminution of their calibre and cerebral anæmia are the direct results. This explanation will be found consistent with the relations of nerve and muscular fibre throughout the body, and is surely much more natural and physiological than to attribute an exciting effect in the nervous centres to the direct influence of poisoned blood.

Either bad blood or deficient blood is a very unfavorable condition for the development of excessive nerve force, for "it is a law in physiology that the functional activity of an organ is directly proportionate to the supply of arterial blood to the organ."*

100. With these considerations in view it is our duty to repudiate the assumption that under the condition of diminished blood supply the nervous centres pass into a state of undue activity, and develope motor nerve-force in an unprecedented manner. And this, too, at the very moment when another portion of the brain—the cerebrum—is so deficient in power as to permit the mind to lapse into unconsciousness, and plunge its faculties in oblivion !

101. Nor do the convulsions occurring during sleep admit of any other explanation than that of diminished and not exalted nerve-power. For we know that during sleep the brain is anæmic, and the blood moves in the cerebral vessels with diminished rapidity.†

102. Nor are puerperal eclampsia an exception to the rule of epileptic seizures generally. This kind of convulsion is not peculiar to plethoric persons, but frequently occurs in pale, ill-nourished and anæmic subjects.

Besides, there are grave reasons for doubting that the state of pregnancy is attended by increased healthy nutrition. The nutritive functions are usually materially disturbed, and this condition in turn induces alterations in the blood,‡ and this fluid "though increased in quantity is more generally impoverished, containing fewer corpuscles, less albumen and a larger proportion of water." We have, conjoined with these conditions, in the majority of cases, a high degree of mental anxiety, not unfrequently œdema, and serous effusions, "by which a considerable drain of the nutritive elements of the blood is produced."

103. Indeed all the circumstances under which eclampsia occur justify the words of Dr. Hughlings Jackson when he says : "All clinical evidence points to this one general conclusion, that nerve tissue is enfeebled in convulsions. Whether it be itself primarily at fault, or whether it suffers from want of blood, is poisoned by bad

* Dr. Radcliffe, Lectures on Epilepsy, etc., p. 238. † Dr. Madden, Braith. Retros., Jan., 1875, p. 241. ‡ Dr. Barnes.

blood, or torn by cerebral hœmorrhage, there can, I think, be little doubt that it is enfeebled." *

104. Dr. C. B. Radcliffe,† approaches this question of excited or depressed vital function, in convulsion, tremor, spasm, &c., by considering how the great functions of respiration, circulation and innervation are affected; believing that the activity or inactivity of these must furnish a correct measure of the degree of vitality in the system at the time. The subject is discussed at considerable length from this point of view, and Dr. Radcliffe finds abundant evidence to show that these important functions are constantly more or less impaired, not only during the convulsions, but frequently also in the intervals between them.

This author shews, among other things, that the strong and full pulse which so often accompanies the fully developed epileptic convulsion, is a pulse of *black* blood, and not a pulse of *red* blood; the pulse of suffocation, the apnæal pulse, which he holds to be quite consistent with the conclusion that convulsion is connected with vital depression and not with vital excitement.

He shows that convulsion and spasm are never co-incident with a state of active febrile excitement of the circulation, and that if convulsions, spasms, &c., occur, in connection with such a state, it is during the cold stage; and he advances reasons for believing that the stage of febrile excitement is actually antagonistic to convulsion.

The convulsions which may attend Bright's disease are believed by this author to be owing to a pale and watery condition of the blood, conjoined, perhaps, with uræmic poisoning; but in any case, with unmistakable signs of great vascular debility, a state quite incompatible with increased vital energy.

105. *The treatment of the epileptic state* is a practical illustration of the truth of the foregoing pathological views. Dr. Anstie says: "The removal of muscular tremor, spasms and convulsion is one of the most striking effects which is produced by stimuli." And again: "The action of small doses of chloroform in arresting convulsive movements affords a good example of the operation of minute quantities of a substance which, in large doses, is a narcotic and paralyzer." He then narrates "a good illustration of the action of small doses of chloroform in cutting short convulsive attacks," which fell under his own notice in King's College Hospital. Elsewhere he assures us that the action of small doses of chloroform, by inhalation, is that of a stimulant, and that the narcotic, or paralyzing effects, are to be carefully avoided, as highly conducive to invoke convulsion. He continues: "The operation of an undoubted stimulant, such as carbonate of ammonia, in a five-grain dose, produces smaller, but precisely similar, effects. . . . . Inter-

*Braith. Retros., July, 1871, p. 204. See also Jan'y, 1875, p. 241-2; and Jany, 1869, p. 227-230 of the same publication. † Lectures on Epilepsy, &c., pp. 158, 166, 191.

mediate between chloroform and ammonia, in the degree of its efficacy in arresting convulsive movements, is alcohol. I have notes of several cases of epilepsy in which I was assured by the patients that they could sometimes ward off a fit completely by taking a tumblerful of hot brandy and water, or a glass of wine, as soon as any threatenings were perceived; and in two very severe cases under my care, alcohol has appeared to be absolutely the only remedy which was capable of mitigating the violence and duration of the paroxysms (chloroform could not be tried); in one case ammonia had completely failed, in the other it produced only trivial effects. In one of these cases I had the opportunity of personally observing the arrest of a fit, which was imminent, by a dose of brandy. I was conversing with the patient, in his own house, when a curious expression of horror and bewilderment passed over his face, he began to stammer in his speech, and the head was jerked several times spasmodically toward the right shoulder. A hot glass of brandy and water was immediately administered, and the sufferer sat down quietly, the convulsive jerks ceased in a minute or two, and although the patient continued trembling and shaking for some time, there was no return of the threatening symptoms. *The convulsions of teething in children* form another class of diseases for which there is very considerable reason to believe that alcohol is one of the best remedies possible. . . . . It it is needless to dwell upon the well-known effects of alcohol in relieving many kinds of muscular spasm; the most familiar instances, perhaps, are its beneficial influence upon colic; and upon spasmodic asthma, in both of which affections it often acts favorably: it is proper to remark, however, that the use of intoxicating doses is entirely unnecessary, and, I believe, indirectly very injurious by the after depression which it causes. I would venture also to express the opinion that the very sensible relief which is often experienced in spasmodic asthma, from the inhalation of the smoke of tobacco and of stramonium, may be procured without carrying their action so far as to produce a truly narcotic or paralyzing effect."

106. Dr. Anstie then proceeds to "consider the measures which are calculated to eradicate the convulsive *tendency*," and here "it is impossible not to see at a glance, that these remedies are all of them probably—the great majority certainly—such as directly tend to improve nutrition. One by one the various sedative remedies appear to lose the confidence of the profession, that is to say, as far as regards their employment in sedative or depressing doses." Cod liver oil, iron, quinine and the bromides of potassium and ammonium, are mentioned as among the principal remedies, all of which "are probably to be looked upon as agents which tend to restore nutrition to a healthy state."*

*Stimulants and Narcotics, pp. 123-129.

The use of the bromide of potassium, and the other bromides, as remedies for epilepsy, will be discussed in the chapter devoted especially to drug action.

107. The phenomena of poisoning by strychnia has been, till recently, regarded as a typical example of "exalted" functional activity of the spinal cord, shewing itself in increased sensibility to external impressions and strongly marked convulsions.

In regard to strychnia, as well as many other drugs, but little is known as to the manner in which they impress the organism. It would excite no surprise in the mind of the professional reader, if the true mode of action of strychnia should, on due investigation, prove to be of a different character from that which has been assigned to it, most probably in deference to the old "doctrine of stimulus," now greatly in need of thorough modification. (Dr. Anstie). The complete reversal of opinion in regard to digitalis is notorious. The acetate of lead, so far from being a dangerous remedy, is now proved to be quite innocuous, and in large doses (without opium) to be a most valuable remedy in post partum hœmorrhage. (See paper read before the Canada Med. Association, September, 1877, by J. Workman, Esq., M.D., of Toronto, to the truth of the facts of which, as taught many years ago by Dr. Workman, the writer takes pleasure in bearing witness). Other examples of modified opinions as to the action of drugs might also be quoted.

Dr. Anstie says of Dr. Harley's investigations of the action of strychnia, that they were the first scientific attempts to elucidate the true range of this drug. He shows that "it is extremely probable that it acts by preventing the oxygenation of the blood, in which case it can hardly be supposed to communicate increased force to the nervous system. Rather would it appear probable that it reduces the muscles to a condition in which they obey the laws of inorganic matter."*

Dr. C. B. Radcliffe makes the following remarks on this subject: "It has been shown by Dr. Harley (*Lancet*, June and July, 1856) that air which has remained for some time in contact with blood, to which strychnia or brucia has been added, contains more oxygen and less carbonic acid than air which has been left in contact with simple blood for the same length of time. It has been shewn, that is to say, that blood poisoned in this manner *respires* less freely than pure blood. . . . that the strychnia has worked a change in the blood which may in one sense be looked upon as equivalent to loss of blood; for blood which cannot become arterial is as good as lost to all purposes of life. Nay, this change may be looked upon as equivalent to copious loss of blood, for in the experiment . . . a very minute quantity of the poison has the effect of depriving the blood of full two-thirds of its natural power of becoming arterial."†

* Stim. and Narcot., p. 72. † Lectures on Epilepsy, &c., p. 91, &c.

Whether this view of the case is to be sustained or not, time and further observation will determine; but we think it worthy of remark, that if the symptoms of well-marked cases of poisoning by strychnia, and death from rapid hœmorrhage, be tabulated, side by side, it will be seen that there is a striking resemblance between them.

108. A patient of Dr. Anstie, 59 years of age, while taking one-sixteenth of a grain of strychnia three times a day, for sluggish circulation and other signs of debility, the remains of previous hemiplegic paralysis, complained that it "made him drunk," and he certainly presented "the uncertain gait, meaningless smile and flushed, perspiring cheeks, characteristic of intoxication." The effect in this case Dr. Anstie held to belong to the poisonous action of the drug, which was here inadequate to produce convulsion, but is, like alcohol, when the latter is given to intoxication, a paralyzer, and "but very ill deserves the name of a stimulant."*

A fact like this is significant, for although a number of "stimulants" produce intoxication, they do not do so *as stimulants.* When this stage of their effects is reached, the proper stimulant effect is past, and the stage of narcosis—which is always one of paralysis—has already been entered upon.†

109. The curious fact may here be stated, that curare and strychnia are derived from plants belonging to the same genus. The action of the ethyl and methyl compounds of strychnia, brucia and thebaia, have been shown by Drs. Crum, Brown and Frazer to have precisely the same character as that of curare; and while retaining most of their chemical properties and giving the ordinary reactions of strychnia, brucia and thebaia, have their physiological action so completely altered, that in place of causing tetanic spasms, they produce general paralysis of the body; an effect shewn by experiments to depend upon paralysis of the motor nerves. In fact these new compounds act on the body in the same way as curare.‡

These facts, with others which may be mentioned, show how very slightly the true action of strychnia was known at the time it was rather hastily set down as a spinal stimulant, and they suggest, moreover, that its true effects have been altogether misinterpreted.

110. In regard to the apparent increase of common sensibility which strychnia occasions, and which shows itself conspicuously between the spasms, Dr. Anstie shows that it is not the result of true stimulation, or of heightened vital activity, for it is accompanied by loss of discriminating power in the organs of special sense, which rather betokens paralysis than stimulation; as is the case also with the apparent excitement of alcoholic inebriation. Besides, with all the apparent excessive muscular activity in strychnia

*Stim. and Narcot., pp. 142, 352. †Ibid. ‡Dr. Sidney Ringer's Therapeutics, pp. 502-3.

poisoning, there is a lack of due balance between the several parts of the muscular apparatus; and whatever thus breaks through the channels of communication and co-ordination between the organs must be a devitalizing agent.

111. The argument that strychnia is not a stimulant to the nervous centres and motor nerves finds support in the means best adapted to antidote its effects. Of the drugs employed for that purpose hydrate of chloral appears to occupy the front rank.* A most intelligent medical friend informs us that alcohol is an antidote of equal value.

112. Although opinions differ considerably as to the mode of action of chloral, there appears sufficient ground for regarding it, in one stage of its operation at least, rather as a stimulant than a depressant to the nervous centres. Thus Dr. Ringer states that it not unfrequently produces great excitement, rather than sleep,† and Dr. W. A. Hammond has seen it produce "great increase in maniacal excitement," and finds that "its first effect is always to augment cerebral congestion."‡ Its good effects in delirium, nervous irritability with wakefulness, the moderate varieties of pain generally, neuralgia, chorea, convulsions, &c., may be in part accounted for by this stimulant quality of its action: for it is well known that stimulants are among the most potent means at our control for the relief of these states.‖

113. The remarkable flushing of the head and face, even in anæmic persons, which chloral frequently produces, has been well attested.§ Dr. Fothergill observes that it dilates the arterioles, especially of the skin.¶ A diffuse inflammatory redness, closely resembling scarlatina, has been noticed by others, so that increased circulatory activity may be set down as among the primary effects of this drug.

114. If strychnia paralyzes the spinal cord, or motor nerves, and thus, by withdrawing the restraining influence of these centres or nerves over the contractility of the muscles, sets the latter free to act, the antidote to strychnia ought to be an agent which, by reinforcing the motor centres or nerves, increases their restraining power over muscular contractility, and thus tends to prevent its irregular manifestation. From what has just been shewn of the effects of chloral, it is not improbable that this is its mode of action, in so far as it antidotes strychnia; for under the theory here advocated, whatever tends to dilate the blood-vessels, does so by increasing the activity of the vaso-motor nerves, and an agent which does this in the case of the vaso-motor nerves may be held to act in a similar way on the *musculo-motor* nerves also.

* Dr. S. Ringer's Therapeutics, pp. 503-4. †Ibid, p. 304. ‡Diseases of Ner. Syst., p. 383. ‖Dr. Anstie, Stim. and Narcot., pp. 113, 114, 371-2. Dr. Radcliffe, Lectures on Epilepsy, &c., p. 213. Dr. Beale, Disease Germs, pp. 395, 401, &c. § Dr. J. Crichton Browne, Braith. Retros., July, 1871, p. 233. ¶ Dr. Ringer, p. 293.

115. It is highly probable that what Dr. Anstie says of the effects of chloroform, in the paragraph now to be quoted, is equally applicable to the action of chloral hydrate:—

"Among stimulants which have the power to arrest convulsive movements, the first rank must be given to chloroform, administered in small doses, by inhalation. It is commonly supposed that chloroform arrests convulsions by inducing a narcotic state, but this idea arises from an imperfect acquaintance with the order of phenomena in the induction of anæsthesia; for, in fact, true narcosis is a state highly favorable to the production of convulsive movements. It is the state of stimulation, produced when only a small dose has been breathed, which puts an end to convulsive muscular movements: to go beyond this point would be to risk their recurrence.*

116. We cannot overlook the fact, however, that there is another side to the action of chloral hydrate than that just presented. In large doses, and in certain states of the system, it shows itself a profound narcotic and paralyzer, and as such produces the very opposite effects on the nervous and vascular system to those noted above.

It may well be doubted, if in this mode of its action it serves as an antidote to strychnia, except in so far as by moderating the violent effects of the spasms on the sensitive nerves, it may retard the fatal event, and so by gaining time for the effects of the poison to pass off, indirectly contributes to recovery. Hypodermic injections of morphia have been resorted to, with favorable effects, doubtless from a similar mode of action.

Professor Bellini recommends the inhalation of chlorine gas as an antidote to strychnia poisoning, and Mr. Wallace† attributes to this gas "an exciting power with respect to the nervous system." The inhalation of chloroform and the administration of calabar bean, &c., have also found their advocates. Astringents like tannin are only of use to prevent the poison from being absorbed: beyond this they are powerless in modifying the subsequent effects.

117. Dr. Ringer says:—"The antagonism between chloral and strychnia is far greater [than between strychnia and calabar bean.] Chloral modifies the strychnia symptoms to a great extent, and as might be expected, the sooner chloral is given after strychnia, the greater is its antagonistic effect. Very large doses of strychnia require very large and even dangerous doses of chloral, enough to produce dangerous symptoms. Whilst chloral antidotes strychnia, it is doubtful if strychnia will avert death from chloral. Chloral destroys life by its action on the cerebral hemispheres, and produces profound coma, but strychnia does not affect these parts.‡"

* Stim. and Narcot., pp. 123-4. † Quoted by Dr. Periera, Mat. Med., vol. 1, p. 381.
‡ Therapeutics, p. 504.

118. *Tetanus.*—As for tetanus, also, on the theory we have here ventured to advocate, it ought to be best cured by remedies which reinforce the nervous centres and motor nerves, rather than by those which depress them. And such we actually find to be the case. If the reader will turn to Dr. W. A. Hammond's "Diseases of the Nervous System," p. 540, he will find a very thorough analysis of the percentage of cures of this disease, by various drugs, a few examples of which we quote.

For instance, calabar bean, a paralyzer of the spinal cord, which on the popular theory should be a complete antidote to an exaggerated "reflex excitability of the spinal centres," effected a cure in thirty-nine per cent. of the cases, only one of which was acute (*i. e.*), occurring within nine days of the injury. Ether effected recoveries in sixty, and chloroform in seventy per cent. of the cases in which they were used, of which five and six cases, treated by each drug respectively, were what is called acute. (Now both ether and chloroform are stimulants to the moderate extent to which they would be applicable in cases like these, where narcosis would be rather a state to be avoided than courted.) Opium aided in the recovery of fifty-seven per cent., twenty-two acute cases and twenty-nine occurring before the fourteenth day. Quinine is credited with the cure of seventy-three per cent., while under the general head of "stimulants," the percentage of cures was no less than eighty—the very highest in the list.

119. It will be noticed, too, that in most of the published cases of cures of tetanus, not only highly nutritious foods were freely used, but that stimulants, in large quantities and frequently repeated, are among the prominent items of the record. Query:—Why should stimulants be admissible at all in a disease essentially depending (as alleged) upon an already unduly excited condition of the nervous centres? Thus in a discussion on tetanus before the Surgical Society of Ireland, Dr. Tyrrell is reported officially as saying:—"*They all knew from the records of the society, that in most of the cases of tetanus which had been cured, the liberal administration of stimulants had been adopted from the beginning, and when the patient did not get stimulants, or was unable to afford them, the case turned out badly.*"*

Facts like the foregoing speak loudly, and we cannot do better than leave them to make their legitimate impression upon the mind of the reader.

120. Furthermore, we have the admission on excellent authority, that tetanus is not always—and if not always, not necessarily—depending on excitation of the nervous centres. Thus Dr. Ringer, in an article to be found in Braithwaite's Retrospect, July, 1877, p. 98, shews that certain poisons, notably gelseminum and buxus

* Dublin Med. Press, 1864, p. 213, quoted in Braith. Retros., July, 1864, p. 55.

sempervirens, produce tetanus in a manner which cannot be attributed to stimulation of the cord, for it is seen that "*the tetanus is preceded by considerable depression of the cord, and continues till the depression ends in extinction of all cord function.*" Indeed, it is said to be "impossible that the tetanus could depend on stimulation of the cord, for it occurred in a dying cord."

The condition of the nervous centres which attends tetanus here is one of depression; and if a depressed condition of these centres is associated with tetanus in one case, it may be so also in others; or may be constantly present, if only the phenomena are properly understood. To show the shifts to which the advocates of the theory which presupposes a stimulated condition of the nervous centres in these cases are sometimes driven, we need only quote Dr. S. Ringer again, and this time from his article on gelseminum, when he says:—"It is interesting to observe that large doses of the alkaloid [of that drug] *at first paralyze*, and then *excite* tetanus, which in a short time gives way to paralysis."*

Is it not a much more rational and scientific view, that the tetanus was the result of the paralysis, and that this state of nervous depression continued throughout the entire process? Or in other words, that the drug by paralyzing the motor centres, or nerves, put an end to the restraining power which these normally exercise over the contractility of the muscles, and the latter, left free to assert their inherent power of contraction, passed into the state of rigidity we call tetanus.

121. We cannot pursue this subject further than to enquire if the nervous centres are already unduly excited, in convulsion, spasm, chorea and irregular muscular contractions generally, how is it to be explained that, as already remarked, among the most valuable remedies for this state are the "anti-spasmodics"—as they are called—but as Dr. Anstie shews,† all of which are really stimulants. Do we then really attempt to cure an over-excited state of the nervous centres by additional free stimulation? The proposition is absurd.

122. Other considerations might be urged, in addition to the foregoing, in support of this proposition; but some of these will find a more appropriate place in future chapters. We may very briefly recapitulate what has already been advanced, as follows:—

1. The fact that contractile power is an inherent and independent property of muscular tissue, renders it unnecessary that a similar power over muscular contraction should be vested in nervous tissue.

2. It has been shewn that when nerve-force may be expected to be acting normally, spasms and irregular muscular contractions are less prone to occur and in fact do not occur, whereas irregular muscular contractions are constantly present in states of the nervous

* Therapeutics, p. 454. † Stimulants and Narcotics, pp. 80, 123, &c.

centres when nerve-force may be expected to be in abeyance or wanting.

3. Since the absence of nerve-force offers the most favorable conditions for muscular contraction, there must be something in the relation of nerve to muscle which retards or restrains the action of the latter. And further, nerve-force cannot act the part of a "stimulant" to muscular contraction.

4. That such is the case is further proved by the well authenticated fact that the best remedies for spasm, tetanus, convulsions, and other abnormal contractions of muscles, are stimulants, the action of which is temporarily to reinforce nerve-power, and so to increase its restraint over muscular contractile power; thus preventing the state in question.

5. From all of which, it is impossible to conclude otherwise than that the function of nerve-force is to restrain muscular contractile power, as asserted in the general principle at the head of this chaptcr.

123. We have to remark here, that we do not claim originality for the views propounded in the two "general principles" thus far considered. The application of the facts and the collation of the arguments by which these views are sustained are, however, entirely our own. But both the independent contractile power of muscular tissue and the function of nerve-force as a restraining power over it, have been asserted long ago. In the appendix to Dr. C. B. Radcliffe's Lectures on Epilepsy, &c., which we have so often quoted, we have found, since commencing to write these pages, that so early as 1832, Dr. West, of Alford, England, published an essay, which practically embodied these views. Prof. Engel, of Vienna, in 1849, and Prof. Stannius, of Rostock, in 1852, have also written on this subject, but their publications have not come within our reach.

Soon after the publication of Dr. West's remarks, Sir Charles Bell gave countenance to these views in a lecture at the Royal College of Surgeons, England, in which he said "that *relaxation* might be the act, and not contraction; and that physiologists, in studying the subject, had too much neglected the consideration of the mode by which relaxation is effected."*

* Appendix to Dr. C. B. Radcliffe's Lectures on Epilepsy, p. 277.

CHAPTER III.

ELECTRICITY:—PARALYZING ACTION OF THE GALVANIC CURRENT.

124. Without an exception, we believe, all who have written on this subject hold that electricity is a stimulus, an alterative, a tonic, or that it possesses one or other of these qualities in combination with sedative effects.* The testimony of these gentlemen will, therefore, be all the more valuable (as unprejudiced and involuntary witnesses) if we can shew, directly and conclusively, from their published evidence, that electricity is an anæsthetic, in some of its effects equivalent to a narcotic, and constantly, to a greater or less degree, a paralyzer; and that the beneficial effects which it undoubtedly accomplishes by its action on muscular fibre, as an aid to local nutrition, are brought about by a greater or less degree of paralysis of the motor nerves which are subjected to its action in the process of its application.

125. Before entering on the main part of this subject we must first, in a few words, invite attention to the present state of opinion as regards nerve and muscle currents of electricity. For the ideas generally accepted on this subject, more especially as regards the supposed existence of a somewhat complex system of nerve and muscular currents of electricity, the scientific world is largely indebted to the exhaustive labors and ingenious experiments of Matteucci and M. Du Bois Reymond. In view of so much industry, one can hardly read, without a feeling of regret, that the conclusions of these eminent electricians have, in recent times, been seriously discredited.

Professor Trowbridge, of Harvard College, has accomplished, with artificial muscles and nerves, all that M. Du Bois Reymond did with real ones; and has thus shewn that the currents in question were derived from chemical action taking place between the moist nerves and muscles and the contiguous metallic electrodes: that, in fact, the supposed currents did not originate in, or belong to, either the muscles or nerves, but were wholly extraneous to both.†

This remarkable announcement clears away a vast fabric of ideas and speculations, which had been built up in connection with this subject. Consequently in our present enquiry we have to deal only with the relations of electricity to nerve and muscle, as it effects these when applied to the surface of the body.

126. It may be as well, here, to clear the ground a little further by remarking that while some arguments can be adduced for

* Dr. Lincoln's Electro-Therapeutics, p. 55, &c. Drs. Beard and Rockwell, Med. and Surg. Elec., 2d Edition, p. 253. † See Beard and Rockwell's Med. and Surg. Elec., 2d Ed., pp. 107–110.

assuming that electricity and nerve-force are, if not identical, at least similar forces, the weight of evidence is altogether to the contrary.

Part of this evidence may be thus stated :—

1st. "All attempts to prove the existence of an electric current in a nervous trunk that is actually engaged in conveying motor influence have completely failed, though made with the greatest precaution."

2nd. The conductive power of a nerve is destroyed by merely putting a ligature around it; but this operation does not diminish its conductive power to electricity.

3rd. Nerve-force is restricted to a particular fasciculus of the nerve-trunk; but electricity diffuses itself not only through the entire trunk, but even through the neighbouring parts in which it is embedded.

4th. If a portion of a nerve be removed, and its place supplied by a piece of wire, or other conductor, electricity continues to pass, but not so nerve-force.

5th. Nerve tissue is inferior to other tissues of the body as a conductor of electricity; its conducting power being not more than one-fourth that of muscle; while, of course, it is the special medium for transmitting nerve-force; to which it may be added that both nerve and muscle are *infinitely worse* conductors than copper.*

127. Does any reader here exclaim: "Why all this ado about how electricity acts? Is it not enough to know that it is a useful agent for the cure of certain morbid states? Why bandy words about the name it is called, so long as its action is beneficial?"

To this we reply :—When we enter the arena of the sick room, to defend our friend, or our patient, from the fell destroyer, is it not of consequence that we know the range and strength of our weapon? When we direct a powerful agent among the life-forces of our brother—an agent which steals its way into the very citadel of life, and feels about his heart-strings—if we are to be the victors in the struggle with disease, and the patient not our victim, is it not of the first importance that we know how this potent agent of ours is likely to conduct itself? There are times when a false light may lure to destruction. A false label is equally to be guarded against. If any medical reader thinks, like Mr. Toots, that "its no consequence," probably his patient, or the public, could hardly arrive at the same conclusion.

128. One more objection to anticipate, and then to our main subject.

It will be said, we know, that while powerful currents may be injurious or dangerous at times, mild ones may be highly beneficial;

* Dr. Carpenter, Physiology, Smith, 5th Am. Ed., pp. 356–7. Drs. Beard and Rockwell, Med. and Surg. Elec., 2d Ed., pp. 249, 258.

just as small doses of deadly poisons, like arsenic or strychnia, may be employed as valuable medicines.

But this argument will not apply here; because unless electricity produces muscular contraction it is powerless for good, of which we shall have abundant evidence by and by; and in order to produce muscular contraction, and thereby attract blood and pabulum to the muscle, a current of sufficient power to paralyze the nerve is indispensible. The case would be different if electricity contributed anything directly to nerve-force or to nutrition, as certain poisons undoubtedly do, in small doses, but electricity is in no sense a food for either nerve or muscle. Its sole advantages are as an indirect aid to the nutrition of the muscular tissues, *through the exercise it gives them*, and it does this, so to speak, at the expense of the nerves.

Thus, then, there is no comparison between the effects of mild currents of electricity and small doses of arsenic or strychnine, which, in proper doses, are in a certain sense food medicines. The proofs of these allegations will more fully appear in their proper place hereafter.

We have felt bound to notice this objection here, because a great deal of misapprehension prevails as to the true range and curative effects of this agent. Our otherwise excellent treatises on medical electricity teach that electricity is "a stimulant." If a nerve is galvanized, it is said to be "excited," or "irritated," while the "tonic" effects of electricity are lauded on almost every page. Meanwhile the quacks, in and out of the profession, are flooding the country with pamphlets and circulars, repeating, as with a thousand tongues, the silly cry, "electricity is life." One of these fly-sheets, now in a double sense *lying* before us, makes this announcement in bold letters, and then its author unblushingly adds, "*Physic kills!*" Thus both the profession and the public are being deceived as to the true nature of electrical action; and to correct this misapprehension is one of the objects of these pages.

Besides, it is easily shown that the use of electricity, even in ordinary diseases, is not confined to the milder or less powerful currents. Galvanic batteries of from ten to one hundred cells are ordinarily brought into requisition; and leading electricians seem to vie with each other in what may be fairly called "heroic treatment."

Thus, Remak won fame by "exciting" the cranio-spinal nerves, in certain conditions, so as to produce what are called "di-plegic contractions." Galvanization of the sympathetic, the great nerve of organic life, as Dr. Lincoln states, "is, in fact, a routine practice with many;" although electricity thus applied, "must of necessity affect the vagus, the depressor, the phrenic and various branches of the cervical plexus, if not that plexus itself."*

* Electro-Therapeutics, pp. 130-1.

Drs. Mitchell, Morehouse and Keen assert that "none of the American batteries for medical purposes have power enough."*

In view of these facts, it is no wonder that "disagreeable symptoms" are sometimes produced, such as dizziness, heaviness, oppression, headache, soreness of the muscles, exhaustion and an indefinable nervousness, to say nothing of occasional fatalities, much more serious.

129. We come now to deal with electricity as applied for medical purposes. The purport of what follows is embodied in our "third general principle," which we here reproduce, and which we hope to prove to the satisfaction of the reader.

Third General Principle.—Electricity is not a stimulus to nerve or muscle. On the contrary, its action is that of a sedative, anæsthetic and paralyzer to nervous tissue. It is through this quality of its action that it soothes pain; while its "tonic" effects depend solely on the indirect improvement in nutrition, brought about by an infinite number of contractions and relaxations of muscular fibre. These spasmodic contractions depend on the same condition as muscular spasms otherwise occurring: that is to say, they depend on a partially paralyzed condition of some portion of the nervous system, setting muscular fibre free to contract, and not on any exalting or "vitalizing" quality whatever.

130. All the authorities on this subject hold that muscular contraction is the direct result of the compelling power of the motor nerves, and that as electricity induces muscular contraction, it does so by acting as a stimulus to the muscles through their motor nerves.

If the validity of the two preceding "general principles," or propositions, be admitted, the currently received opinions will require complete modification. We shall then find it necessary to believe:—

1st. That muscular contractility is independent of nerve-force.

2nd. That the motor nerves exert a restraining power over muscular contractility.

3rd. That when muscular contraction prevails, motor nerve influence is cut off, or paralyzed.

4th. Consequently, that as electricity produces muscular contraction, it does so *by paralyzing the motor nerves:* since if these nerves were not paralyzed, they would have prevented the muscles from contracting.

Thus, the truth of this "third general principle" follows, as a matter of course, on the recognition of that of the two former. If these were proven, then this one, too, is established, for they all stand or fall together.

Here, then, we might, perhaps, dismiss this part of the subject; but as it is one of importance, and further evidence awaits pro-

* Gun Shot Wounds, &c., Note, p. 142.

duction, which may strengthen our case, we proceed to discuss it further.

131. Electricity, as now used for medical purposes, is chiefly of two kinds, namely, the "continuous" and "interrupted" currents. As each of these differs in the mode of its production, and also in the intensity of its effects, it will save confusion and be more methodical if each be considered separately.

This is the more necessary, since, while both kinds of electricity may relieve pain, the continuous current is more specially adapted for that purpose;* while the effects on nutrition, as we shall see, are brought about to a greater degree by means of interrupted, or faradic electricity.

We shall, therefore, first consider the phenomena of the continuous (or galvanic) current, premising that where the term "current" is applied in this connection, it is used simply for convenience of expression, and not in its literal meaning.

CONTINUOUS OR GALVANIC ELECTRICITY.

132. Galvanic electricity is also called *constant*, or *continuous*, to distinguish it from the interrupted or faradic current. It is sometimes referred to as the *voltaic*, and also as the *battery* current. It is produced by chemical action in one cell, or in a series of cells associated together. It is a kind of electricity which is said to be of large quantity and *low tension*. In batteries producing this kind of electricity there is no helix, and no interrupting spring; but the current flows on continuously and noiselessly. It produces little or no pain, except a slight prickling or burning sensation in the skin at the points where the application is made. This surface irritation will be more apparent if the skin is tender or abraded, or if a very strong current be used.

133. Dr. C. B. Radcliffe, in the lectures already quoted, lays it down (p. 64) as his 16th proposition:—

"*Continuous currents of low-tension electricity, such as the common galvanic current, have a paralyzing influence upon motor nerve and muscle.*" He proceeds to prove this as follows:—"If the spinal cord of a rabbit be included in the circuit of a voltaic battery, and the current allowed to pass for a few moments, the part between the poles may be cut, pricked, torn, or even exposed to the shock of a coil machine without giving rise either to pain or convulsion. (Matteucci). . . . Whether the current was passed up the spine or down the spine the result was the same so far as the paralyzing action was concerned. . . . There are also several beautiful experiments by Professor Eckhard, of Giessen, which show that the action of the continuous galvanic current upon the nerve of a

* Drs. Beard and Rockwell, Med. and Surg. Elec., 2nd Ed., p. 472. Dr. Anstie, Neuralgia, p. 252. Dr. Lincoln, Electro-Therapeutics, p. 119-120.

rheoscopic limb [of a frog] is to produce a state of paralysis in the part within the circuit, and that this is the case equally whether the direction of the current be up the nerve or down the nerve. In a word, there are sundry facts which show that the continuous current of low tension electricity upon a motor nerve is altogether different from that of the instantaneous currents of high tension electricity; that instead of producing action, it produces paralysis."*

Drs. Beard and Rockwell also testify to the same "paralyzing effect" of this current. They say:—"The cord remains insensible to any stimulus that may be applied to it, as long as the current is passing."†

Dr. Moritz Meyer refers to the observations of Valentine, Matteucci and Eckhard in this connection, and bears witness to the effects of the constant current, when it traverses a portion of a nerve with a given intensity, rendering it "incapable of transmitting contraction-producing stimulus" to the muscles. He concludes:—"In other words, *the nerve is paralyzed* so long as any portion of it is subjected to the action of a continuous current."‡

134. It will be noticed that these observations are couched in terms which embrace the popular theory. Electricity is assumed to be a stimulant to the nerves, and when this "stimulus" does not result in muscular contraction, it is said to paralyze the nerves and muscles. Apart from considerations as to the logical consistency, or otherwise, of the conclusion thus formed, one fact is obvious, that the profound anæsthesia recorded shews that so far as the nerves are concerned, they at least are completely paralyzed.

If it be said that the state of the cord, or nerves, under this current, which permits it to be cut, pricked, torn, &c., without pain, is one of anæsthesia, and resembles the effects of ether or chloroform, rather than paralysis, we answer that the two conditions are analagous. Dr. Anstie describes the anæsthetic state as "a regular and progressive extinction of the vital properties of the nervous system. . . . . A state of paralysis which spreads from periphery to centre; which involves the brain, the sensory and motor nerves, and the sympathetic system to nearly an equal extent."‖

It is true that the paralysis of electricity is of short duration; and when the current ceases to act on the nerves, they speedily recover their wonted function: but that it *is* paralysis while it lasts, we think the foregoing facts fully prove.

135. As for the non-appearance of muscular spasms under the influence of the continuous current, as mentioned in the experiments just quoted—which contractions ought to occur according to our theory when the motor nerves are paralyzed—we have to say, that

* See also Periera's Mat. Med., vol. 1, p. 102, § 5, for a similar statement in the language of Matteucci. † Med. and Surg. Elec., 2d Ed., p. 127. ‡ Elec. in Prac. Med. (Hammond) p. 62. ‖ Stim. and Narcot, pp. 273-328.

the galvanic current of moderate strength, either from its low intensity, and consequent less penetrating power; from its limitation to certain portions of the nervous tract; or from its failing sufficiently to paralyze the motor nerves, as to set the muscles free; or from all these causes combined, frequently produces anæsthesia and partial paralysis of nerves, without at the same time inducing spasms or contractions of the muscles supplied by these nerves. But, under the more intense forms of electricity, when the nervous paralysis may be assumed to be complete, these contractions notably do occur, not only from faradic, but from galvanic currents also.

Thus Drs. Beard and Rockwell say:—"When very powerful galvanic currents are applied continuously to the nerves, tonic contractions are produced during the whole time that the current is closed. . . . . These are called galvano-tonic contractions, to distinguish them from the clonic contractions produced by the faradic current."*

Dr. Radcliffe asserts that "in animals killed by repeated discharges of a Leyden battery, or by repeated shocks of a Ruhmkorff's coil, there is actually no appreciable interval between the spasms preceding death and the stiffness attending death."†

Thus any apparent difficulty arising out of the absence of muscular contractions in the experiments of Matteucci and others, finds an easy solution.

In order, however, to do full justice to these experiments, it is necessary to notice, what the reader will find if he refers to the full account of them, namely, that Matteucci believed from experiments on frogs poisoned by strychnia, that electricity was likely to prove an antidote to the effects of that drug. It is needless to say that this expectation has proved illusory, and no author now thinks of mentioning electricity in this connection. The fact is that both strychnia and electricity favor the early occurrence of *rigor-mortis*,‡ a sure indication that both hasten the extinction of the vitality of the nervous system. So also in regard to Matteucci's case of tetanus,‖ electricity appears to have mitigated some of the painful symptoms, and nothing more. This effect is fully accounted for by the paralyzing effects of electricity on sensation; for, as we shall see, by and by, it is of no value in spasmodic states.

136. Drs. Beard and Rockwell mention that the more the application of galvanism is prolonged, the more vigorous are the tonic muscular contractions, up to a certain point. They account for this by the skin becoming more moist, hyperæmic, and a better conductor.§ But a prolonged application may equally be held to

* Med. and Surg. Elec., 2nd Ed., p. 157. † Lectures, &c., p. 63. ‡ Dr. Carpenter's Human Physiology, p. 333. ‖ Dr. Periera's Mat. Med., vol. 1, p. 102. § Page 157.

produce more profound paralyzing effects on the nerves, permitting a greater freedom to the muscles to contract.

137. *The relief of Pain.*—The paralyzing effects of the galvanic current, which we have just seen, are amply sufficient to account for the relief it affords, though often only temporarily, in painful affections. Like narcotics generally, electricity blunts sensation, and stultifies the sense of pain either in the nervous branches originating or transmitting the painful impressions, or in both. But unlike narcotics, which, if taken into the system, influence the greater part of the organism, the powers of this subtle agent are limited to the parts which it impresses, either directly or by reflex action.

It may be said that the mere prevention of the sensation of pain is not removing its cause, or curing it. The objection is an old one, and applies equally against anodynes generally. But every intelligent physician knows that pain, if unrelieved, tends to perpetuate itself; and that, as a matter of fact, to *relieve* certain kinds of pain is a great step towards *curing* them.

"Is there pain to be relieved?" is the first question (say Drs. Beard and Rockwell) to be asked and answered when the propriety of using electricity is under consideration. If the answer be in the affirmative, and the pain is relieved by electricity, then the theory here advocated presents a reasonable explanation of its mode of action, quite apart from any assumed stimulating, tonic or vitalizing quality of its action whatever.

138. *Other morbid states.*— Not only is the cure or mitigation of purely neuralgic pains thus accounted for, but so also is the benefit obtained in a great number of morbid states, *depending on direct or reflex irritations of some part of the nervous circuit.* The number of such diseases is greater, perhaps, than is generally supposed. Among them are congestion and inflammation of the eye, and of other organs; alterations of the cornea; amaurosis, anæsthesia, syncope, epilepsy, tetanus, muscular atrophy, herpes-zoster, erythema, pemphigus, urticaria, hypertrophy of bone, ptyalism,* diabetes,† influenza,‡ œdema and dropsy,‖ ptosis, unilateral sweating, difference in the temperature of the two sides of the body, local lividity or pallor, atrophy of skin, nails, or cellular tissue; hypertrophy of the skin, local hyperæmia or anæmia, mydriasis, myopia, &c.,§ most or all of which, and probably other morbid states, may be traced to a direct or reflex irritation or excitation of some part of the nervous system.

It need excite no surprise that an agent like electricity, which can be brought to exert its benumbing influence over every part of the nervous system, should be found useful in the various irritated states, often apparently widely different from each other, which

* Dr. Brown-Sequard, Phys. & Path., Central Nervous Syst., pp. 157, 207.
† Braith. Retros, July, 1871, p. 106. ‡ Copeland's Dictionary of Med., Vol. 2, p. 430.
‖ Dr. B. W. Richardson, Disc. on Prac. Physic, pp. 62-3. Brit. Med. Times, June, 1872.
§ Dr. Lincoln's Electro-Therapeutics, p. 133.

depend upon direct or reflex impressions of one part or another of the ramifications of that system.

The theory here advanced accounts for the beneficial effects of electricity in curing or mitigating these irritated states. Drs. Beard and Rockwell state, that "in the great majority of nervous diseases . . . . sedation is more needed than stimulation."* Under the view of electricity here shown, we have the necessary "sedation" to the excited or irritated nerves, plainly and naturally resulting from its use.

139. Before dismissing this part of the subject it is incumbent on us to notice the following opinions, which seem to negative the foregoing views of the paralyzing action of electricity. They are the opinions of Volta and others, in the first years of the present century, and are thus summarized by Dr. Pereira:—

"The electric current acts like other stimulants on the nerves of sensation, and excites the special function of each nerve. Thus when transmitted to the nerves of touch it excites pain, the shock, and other disagreeable sensations; along the optic nerve it causes the sensation of light; along the gustatory nerve, a remarkable taste; along the auditory nerve, a sound; and along the olfactory nerve, a sense of smell."† What is here stated, however, is more apparent than real. Sensations are felt when the nerves are only partially paralyzed; pain and shock when other nerves, not directly acted on by the current, are pressed upon violently by the sudden contraction of the muscles which they traverse, or, perhaps more probably still, by an alteration of their normal molecular vibrations, resulting from the more active disturbance in the molecules of adjacent nerves or tissues, for there is reason to believe that pain results from a dynamic perturbation in non-nervous tissue, continued along the nerves transmitting it.‡ These nerves being apart from the direct range of the electric current, are still able to transmit a note of warning to the seat of consciousness, and hence "the pain, shock, and other disagreeable sensations referred to."

The sensations of light in the eye, produced by electricity, are also occasioned by a gentle pressure in the corners of the orbit, accompanied by a slight movement of the finger, or by a blow, even in the dark. Prof Huxley says:—"It is doubtful, however, whether these effects of pressure or shock, really arise from the excitation of the retina proper, or whether they are not rather the result of the violence done to the fibres of the optic nerve apart from the retina."‖ They appear to be simply the results of vibratory sensations, consisting in molecular changes, transmitted along the optic nerves to the central organs of vision, and as these resemble in character the impulses transmitted along the nerve resulting from the undulations of light impinging on the retina, they are translated as such by the

* Page 267. Dr. Meyers also, p. 305. † Materia Medica, Vol. I, p. 95.
‡ Dr. Anstie, Neuralgia, p. 12. ‖ Elementary Physiology, p. 222.

mind in the process of perception. For it must be remembered that "vision is, in fact, the art of seeing things which are invisible" (Dr. Brown) "that is of acquiring information by means of the eye which is neither contained in the sensations of sight themselves, nor logically deducible from the intimations which those sensations really convey."*

The sensations of light referred to, however, are produced by mild or moderate currents. If the charge of electricity be sufficiently strong, neither the optic, auditory, nor any other nerve, will continue to transmit vibratory sensations; but complete arrest of function will result, and total blindness or deafness may follow, as has actually been the case in a patient of Duchenne, who suffered "a total destruction of sight immediately after galvanization."† Here is a further practical proof, if such were needed, of the paralyzing action of electricity. Mild currents produce "a tingling or numbness;" stronger ones, "a decidedly anæsthetic effect;" and if the current be increased, the "benumbing" or paralyzing process is complete. (§ 145). These several effects are but progressive stages of one uniform process swiftly leading to paralysis of nervous tissue, which corresponds to the similarly uniform process by which narcosis —that is, paralysis—is produced by drug action.‡

Such is our reply to the statements contained in the quotation above made. In the first issue of a work of this kind it is impossible to anticipate all objections; but we trust the candid reader will perceive that we do not seek to shrink from, or conceal, at least the more obvious of these.

THE GALVANIC CURRENT INTERRUPTED.

140. Before leaving the consideration of galvanic or continuous electricity, it is necessary to notice the effect produced when this current is interrupted. A continuous, interrupted current sounds like a hybernicism; but what we have to say here is very important to the general subject.

The galvanic current, as from a Stohrer or other battery, or from a series of Smee's, Grove's, or other cells, may be "interrupted, not only by opening the circuit in the metallic part, or by withdrawing the sponge electrodes from contact with the body, but by even *moving them by a gliding motion while still maintaining contact with the surface of the body.*"‖ When this is done the quality of the current undergoes a marked change. It then closely approximates in character and effects to the faradic or interrupted current of the coil machine.

* Dr. Carpenter's Human Physiol., p. 890. † Drs. Beard and Rockwell, Med. and Surg. Elec., 2nd Ed., p. 640. ‡ Dr. Anstie. ‖ Dr. J. Russell Reynolds, Lec. on Clin. uses of Elec., pp. 73, 97.

Dr. C. B. Radcliffe explains this modification of the galvanic current as follows:—"There is reason to believe that the condition of the galvanic current at these moments [of opening and closing the circuit] is widely different from that which obtains in the interval between these moments. . . . . There is, indeed, reason to believe that the galvanic current is traversed, at the moments of closing and opening, by instantaneous currents of high-tension electricity."* We have already seen the effects of galvanic or *low-tension* electricity on the nerves when a current of *moderate* strength is employed, and that it often, indeed generally, produces anæsthesia and a profound degree of paralysis of the nerves without inducing corresponding muscular contractions. The effects of faradic or *high-tension* electricity have yet to be noticed; but it may be said here that they differ from the former in that muscular contraction is a special feature which attends the interrupted current; and especially the interruptions of the galvanic current, which we are now considering. Indeed, muscular contractions can be produced by interrupting the galvanic current, after failure to effect this by the use of the ordinary interrupted or faradic current of the coil machine.† And this result occurs, notwithstanding that both forms of batteries furnish simply modifications of the one agent—electricity—and, also, notwithstanding that both these modifications of electricity produce paralysis of nervous tissue.

141. From what has been said above, it will be obvious that the same galvanic battery may furnish either a continuous current of low-tension, or an interrupted current of high-tension, producing a different effect; and this change of current and effect may be brought about by the simple and perhaps almost unheeded movement of one or both of the sponge electrodes from one part of the surface to another, while still in contact with the body of the patient.

Thus, without care, the operator may really be employing one of these modifications of electricity, while intending to employ the other: and, worse still, if he cure his patient and report his case, he will not only have deceived himself, but will deceive others, as to the value of one kind of electricity in a certain ailment, whereas the credit in reality belonged to the other form of electricity. There is no doubt that this error has frequently been made. Here is an illustration. Dr. M. Meyers says:—"Benedict used the constant current in paralysis of the muscles of the eye, and has published the following: He placed the copper pole on the forehead and *stroked the cheek* with the zinc pole for several minutes, &c."‡

Here the galvanic, or continuous, current was nominally being used: but as by moving the electrode in "stroking the cheek," the circuit was "opened and closed," "made and broken," or interrupted, we have what would have been a low-tension current had the

* Lectures on Epilepsy, Paralysis, &c., p. 66. †Drs. Beard and Rockwell, p. 332.
‡Elec. in Prac. Med., p. 152.

poles been stationary, transformed into a current of high-tension, in all respects similar, only more powerful, to the faradic or interrupted current of the coil apparatus. That the current is really interrupted by such a movement as stroking the cheek we have the high authority of Dr. Reynolds, already quoted, and that interrupting the galvanic current materially modifies it, we have the evidence of all electro-therapeutists; while Dr. Radcliffe has furnished the reason for the different effects thus produced.

The same considerations apply to the mode of "central galvanization" recommended by Drs. Beard and Rockwell,* "one pole—usually the negative—is placed at the epigastrium, while the other is passed over the forehead and top of the head; by the inner borders of the sterno-cleido-mastoid muscles; from the mastoid fossa to the sternum and down the entire length of the spine."

What is here recommended to be done, under the name of galvanization, is, in reality, a form of faradization, almost identical with a vigorous current of ordinary, interrupted, or high-tension electricity, and any benefit which follows to the patient ought certainly to be credited to this latter kind of current.

142. It should be specially noted, that if the advantages of the true galvanic current are desired, *the poles, or electrodes, must be kept stationary.* Dr. Anstie insists strongly on the necessity of avoiding anything which may cause interruption, or even variations in the galvanic current, when used for the treatment of neuralgia. The current, he says, must be not only continuous but *constant.*† Here it is desired to obtain the simple anæsthetic and paralyzing effects of low-tension electricity, and to avoid the muscular commotion brought about by the high-tension electricity of an interrupted current.

Drs. Beard and Rockwell are not unaware of the different effects alluded to; for they say elsewhere in the same work, "In beginning to treat a patient by central galvanization, we should use very mild, scarcely perceptible currents, particularly round the head and neck, and even on the cervical spine, and *great pains should be taken to avoid breaking the current*, and the application should be only of a moment's duration."‡

This briefness of the application is intended to avoid the giddiness or tendency to syncope, which is not unfrequent in galvanization of the central nerves. With this object in view it is very proper and prudent. But in so far as it affects the quality of the current it is most objectionable. For what is the result? The closing and opening of the galvanic circuit are only separated by a momentary interval. At both the opening and closing, currents of high-tension are flashing along the conductors, and it is these that the patient receives, and not the soothing flow of a continuous current,

* 2nd Ed., p. 412. † Neuralgia, p. 253. ‡ Page 422.

as was intended. If any benefit follows, it is the interrupted or high-tension electricity, and not "galvanization," which is entitled to the credit.

Perhaps a better method of avoiding both "the unpleasant symptoms" and the high-tension currents, would be to begin the application with an imperceptibly weak current, and then, with poles stationary, gradually increase the strength of the current to the desired point, and as gradually reduce it to zero, when the poles may be withdrawn. Even this plan will not ensure the constancy desirable; but it may prove least open to objection.

We think the above facts and considerations fully establish the truth of the first part of our "third general principle." The remainder of the facts asserted, as regards the "tonic" effects of electricity, will be considered in connection with the faradic current, with which they are most prominently associated.

CHAPTER IV.

THE FARADIC, OR INTERRUPTED CURRENT OF ELECTRICITY.

143. This kind of electricity has too many synonyms. It was discovered by Faraday in 1832, and bears his name. It is a current *induced* in a coil (or coils) of wire, by a primary galvanic current, traversing a circuit in the interior of the coil. Hence the apparatus which produces it is called an induction battery. For the reason given, it is called a *secondary* current. And inasmuch as this current only exists at the moments when the first current in the primary circuit begins and ends, or is made and broken, it is also called an *interrupted* current. It is sometimes called an *instantaneous* current, because it ceases almost as soon as begun; but with a very rapidly vibrating spring as an interrupter, the flashes may be made to succeed each other with great rapidity, so as to produce a sensation of almost continuity. As the induced currents attending the opening and closing of the primary circuit, traverse the coil in opposite directions, the poles being thus alternately reversed, the united effect, unless modified by special arrangements, is a *to and fro*, or alternate current. Thus the several names here placed in italics are all applied to one and the same kind of electricity. Besides, it is a current of low quantity, and *high tension*.

The instrument-makers profess that their electrical machines furnish both the galvanic and faradic currents; but, practically, this is untrue and impossible, unless where special and separate arrangements are made for both, by actually enclosing two separate apparatuses in one box, which would be unwieldy from its bulk.

144. We have now to consider that part of our "third general principle" which asserts that the "tonic" effects of electricity depend solely upon the improved nutrition, brought about by an infinite number of contractions and relaxations of muscular fibre.

We have already quoted Drs. Beard and Rockwell as to the first question to be asked and answered when electrical treatment is proposed, namely :—"Is there any pain to be relieved?" and we have shown the special adaptation of the galvanic current for the relief of painful conditions. We now quote their second question to be asked and answered with a view to electrical treatment, namely, "Is there any need or chance for improvement in local or general nutrition?"* We propose here to show the special adaptation of the faradic current for this purpose.

145. *Paralyzing effects of the faradic current.*—Perhaps, before proceeding directly to this part of the subject, it may be as well to produce the authorities to show that faradic electricity produces sedative, anæsthetic, or paralyzing effects, as does the galvanic.

Drs. Beard and Rockwell bear personal testimony to the truth of this. They say :—"There is no question that electric currents do have a benumbing effect. The result of various experiments that we have from time to time performed in this department, seem to be conclusive. We have had teeth extracted while a strong faradic current was passing through the jaw, and feel assured, from personal experience, that the electricity caused the pain to be less severely felt. That the pain caused by the prick of a pin, for example, is less sensitively felt when a strong faradic current is passing through the part where the puncture is made, we have practically demonstrated on the hand and other parts of the body."†

These authors quote Althaus to the same effect, and add, that Knorr, of Munich, has availed himself of the anæsthetic effects of electrization for opening felons and buboes. Again, "In rhinitis, pharyngitis and laryngitis, we have for three years been accustomed continually to make use of the benumbing effects of electrization." Finally, "A French physician, M. Victor Revillout, has obtained similar results from applications of the faradic current to the uterus after cauterization."‡

The "benumbing effects" referred to, as before remarked, correspond to similar effects produced by narcotics; except that the effect of electricity is more localized, and passes away with greater rapidity.

Drs. Beard and Rockwell more than once refer to the "numbness," "decidedly anæsthetic," and "benumbing effects" of both the galvanic and faradic currents,‖ expressions which are not at all consistent with the assumed action of electricity as a "stimulus." Indeed, it may be safely taken for granted that the adoption of this term in

*Page 263. †Med. and Surg. Elec., 2nd Ed., pp. 122-3. ‡Ibid, p. 123.
‖Ibid, pp. 306, 379, &c.

the case of electricity, as in that of a pinch, burn, or the application of a chemical irritant, such as a dilute acid, before referred to, resulted not from any proof that a stimulant action was really excited, but solely as from the readiness with which it seemed to explain the prevalent theoretic opinions of the time as to the relations of nerve and muscle. Thus the exigency of a theory, and not any real foundation in fact, led to the action of electricity being called a stimulus. (§ 86.)

146. *The production of muscular contraction.*—The great *forte* of the faradic current is the production of muscular spasm. The experience of thousands of persons, who, at one time or another, have "taken a shock," would confirm this statement. That this is its effect when made to act on the nervous centres, we have the authority of all electricians. Dr. Moritz Meyer says:—"If we allow the current of a rotary machine [faradic] to work on the spinal marrow, by bringing the upper and lower ends of the same in connection with the two poles, there arises a general and rigid cramp of all the muscles of the body and extremities, since all their nerves spring from the spinal marrow."*

Drs. Beard and Rockwell say:—"Labile or stabile [moving or stationary] interrupted currents are best adapted to produce muscular contractions."†

As this, then, is the characteristic effect of this current, its beneficial effects, when present, must be sought in this quality of its action.

147. The theory here advocated offers a ready explanation of the mode in which this result is brought about. By paralyzing for a moment the motor nerves, the inherent contractile power of the muscle is permitted to come into play, and contraction takes place accordingly, followed the next moment by relaxation. If the shocks follow each other with great rapidity, the spasms occur in such rapid succession as to appear almost continuous. And just in proportion as this is the case, does this current approximate to the galvanic, or truly continuous current, for the relief of pain: while in proportion to the coarseness, or slowness, of the successive electric throbs, will be the effects exerted on the muscles.

148.—*Improvement in local nutrition.*—Not only is the muscle as a whole thus exercised, but each fasciculus and individual fibre is subjected to alternate contractions and relaxations. This is to do for the muscle and all its parts, and for all other muscular structures brought within the circuit, what is equivalent to active exercise: and if this be not continued to weariness, against which there is a reiterated warning, the effect can hardly fail to be beneficial *to the muscular apparatus.*

* Elec. in Prac. Med., p. 75. †2nd Ed., p. 370.

Increased muscular activity augments the temperature, and attracts an increased supply of blood.* With this necessarily comes more pabulum and an increase of local nutrition.

That this is the real manner in which electricity exerts an indirect "tonic" effect, and not by any direct "vitalizing" influence on the system, is evident from the nature of the case, and is proved by what follows:

Drs. Beard and Rockwell assure us more than once, indeed they reiterate it, that "the leading and general effect of localized electrization . . . is improved nutrition."† And again, "To accomplish improvement in nutrition is the great object of electrical treatment."‡ They even show how this improved nutrition is brought about; and excepting that they refer the effect to the "stimulating" effects of electricity on the nerves, their explanation of the process agrees exactly with what has been advanced above.

They say of the faradic current:—"The powerful and tonic effects [of this current] . . . . are partly and quite largely due to the passive exercise and consequent oxygenation and other important changes in tissue that result from *the several thousand muscular contractions that take place during an ordinary sitting.*"‖

Again, "These mechanical effects of the faradic current are due to its rapid interruptions, which cause contractions, not only of the muscles, but also of the contractile fibre cells, thus stimulating the circulation, and with it the processes of waste and repair. In this respect its action is similar to that of rubbing, pounding movements and vibrations. These mechanical effects are especially indicated in the treatment of diseases of the abdominal viscera, which are supplied with contractile fibre cells; anæsthesia and general muscular debility."§

149.—*An objection answered.*—It may be asked, why it is, in the case of "mixed" nerves, where sensory and motor filaments are found in the same nerve trunk, both are not uniformly paralyzed. We answer, that such is frequently the case; and the exceptions to the rule are to be accounted for in the same way as one endowment of a mixed nerve escapes in wound, injury or disease, while the other may be paralyzed. It has been suggested that this may be owing to the grouping of the fibres of motion and sensation in different bundles, thus comparatively isolating each; or that there may be differences of structure or sensitiveness which make one more liable to suffer than the other.¶

150. *Why the muscles are not equally paralyzed with the nerves.*—The enquiry will also be pertinent, "If the electric current paralyzes a motor nerve, why not also paralyze the muscle?" The answer is easy. Nerves and muscles are not similarly affected by this agent.

* Dr. Carpenter's Phys., pp. 315, 329. † 2nd Ed., pp. 379, 409, &c. ‡ Ibid, pp. 284, 265, 271. Dr. Meyer's Elec., pp. 373-4. ‖ Page 300. § Ibid, p. 300. ¶ Drs. Mitchell, Morehouse and Keen, Gunshot wounds and other injuries, pp. 18, 19.

The phenomena of "electrotonus" displays itself only in that portion of the muscle between the poles; while in the nerve the influence extends for a distance along the nerve outside the poles.* Nor is this all. Dr. M. Meyers assures us that nerves possess a greater "electrical irritability than the muscles," and in a note† of his book he quotes M. Claude Bernard to the effect that the motor nerves are more irritable than the sensory, and that muscles are much less so than nerves.

Dr. Radcliffe has shewn that the resistance offered by the nerves to a current of electricity is nearly three and a-half times greater than that offered by muscles.‡

Now, it appears established that "all conductors of electricity become heated more or less *in proportion to their resistance*" to the current. The tissues of the body are no exception to this rule.‖ From this it is reasonable to infer that the general, as well as the thermal, action of electricity is more intense on animal tissues, in proportion to their resistance. The skin and bones are poor conductors, and the effects of electricity on them would seem to justify this inference. Let us apply this to the badly conducting nerves, and we shall see good reason, according to Dr. Radcliffe's figures, why electricity should impress or paralyze them more intensely than the muscles: because in proportion to the greater resistance offered by the nerves to electricity, will be the effects it displays.

151. *Another objection,—Facial paralysis.*—We can fancy the intelligent reader objecting to the theory here advanced, from what occurs in unilateral facial paralysis. He will naturally say that here, as a matter of fact, the face is drawn towards the healthy side, the muscles of which remain all powerful; while those of the paralyzed side, although liberated from the restraining control of their motor nerves, fail to pass into a state of contraction, as muscles so conditioned, on this theory, ought to do.

He will even tantalize us by the behavior of the orbicularis palpebrarum muscle, supplied by the facial nerve, the conduct of which may appear specially embarrassing to our theory, since it not only shows no sign of contraction itself, but allows the levator palpebræ, which derives its nervous supply from the motor oculi, and is in a provokingly healthy condition, to keep the eyelid permanently open.§ Here, again, he will tell us, it is the muscle alleged to be held in bondage by nervous restraint,—that is the healthy muscle,—which contracts; while the paralyzed ones, which ought to be "free to assert their inherent contractility," to use our own words, flatly refuse to do so. In short, he will evidently feel that the situation threatens to become serious for the success of our theory; which appears already exploded by this vigorous bomb-shell!

* Dr. Lincoln's Electro-Ther., p. 52, &c. † Page 145. ‡ Drs. Beard and Rockwell, pp. 181-2. ‖ Ibid, pp. 189, 161-2. § Dr. W. A. Hammond, Diseases of the Nervous System, p. 722.

It may help us out of our seeming dilemma, if we, in turn, ask a question. Suppose the accepted theory to be correct, that electricity is a stimulus to muscular contraction, how do you account for the fact that in facial paralysis from brain disease the muscular contractility under electricity is usually perfect, and may even be abnormally increased;* while in the same paralysis of *peripheral* origin, neither the galvanic nor faradic currents, however powerful, are able to cause the muscles to contract. What is your "stimulating tonic" about here that it does not "vitalize" the nerve, and, acting as an *alter ego* of the nerve-force, compel muscular contraction? How do you account for the singular and unexplained fact that after failure of the continuous galvanic and faradic currents in these cases, the slowly interrupted galvanic current succeeds in producing the desired contraction, and in this way, through the muscle, aids in restoring the lost function?†

The difference in effect between the latter and the former kinds of electricity you cannot explain, at least Dr. Reynolds states that it has not yet been explained (p. 29); for on the accepted theory these several kinds of electricity should all be "excitors" or "stimulants" to nerve action, and through this to muscular contraction.

Doubtless, you will find it necessary to attribute the non-contractility of the muscle, under the circumstances stated, to the fault of the muscle itself, and not to the nerve. This is the view taken of the cause of peripheral facial paralysis by the authorities.‡ The patient has been subjected to a current of cold air, or to prolonged exposure at a low temperature; the blood has been driven from the cheek to the interior organs; the muscular fibre cells have suffered a deprivation of their customary pabulum, and, as a result, are now unable to fulfil their wonted functions. Perhaps also that unknown factor which attends the rheumatic state, may also contribute its quota to bring about this result. So far your explanation is orthodox, and your pathology will suffice for us.

How is this state best remedied? Let Dr. W. A. Hammond answer:—By promoting healthy nutrition generally, and of the muscles in particular. This is to be done by tonics, by passive exercise, kneading the muscles, &c., and the persistent use of electricity. "If the induced current will cause the muscles to contract, it should be used; if this will not cause contraction, then the interrupted galvanic current is to be applied."‖ Drs. Beard and Rockwell (p. 520), and Dr. Reynolds also (pp. 28-29), testify to the good effects of the latter kind of electricity.

* Dr. Reynolds, Lec. on Clin. uses, p. 37. Braith. Retros., July, '70, p. 55. † See Dr. J. Russell Reynolds's Lec. on Clinical uses of Elec., and Drs. Beard and Rockwell's Med. and Surg. Elec., 2nd Ed., for these facts, in their remarks on facial paralysis. ‡ Dr. J. R. Reynolds, Lec. on Clinical uses of Elec., pp. 27-8. Dr. W. A. Hammond, Diseases of Nervous System, p. 727. ‖ Diseases of Nervous System, p. 730.

Having thus established the pathology and the treatment—which latter confirms the accuracy of the former—let us see how the case stands.

An enfeebled muscle, unable to exert its normal contractility, is more than ever dominated by a nerve, whose functions are unimpaired. The balance of power is altogether in favor of the nerve; and this is why instantaneous currents of faradic electricity, or mild continuous currents, in many cases, fail to paralyze the restraining power of the nerve sufficiently to restore the equilibrium between the nerve and muscle. It should have been said not only to restore the equilibrium, but it is necessary even to give the preponderance to the muscular fibres before they can produce contraction. To accomplish this, requires, in many cases, the more intense effects of the slowly interrupted galvanic current (§140) by which the restraining motor nerve is sufficiently paralyzed to permit the flicker of contractility left in the muscle to exert itself. If contraction occurs at all, however feebly, the prognosis is favorable; because, as we have seen, the nutrition of the muscle is in this way improved. (§148). As improvement is effected, and the contractility of the muscle increases, a lower grade of nerve paralysis will suffice, and at this stage the faradic current will be found amply sufficient.*

The view of the case just presented has the advantage not only of accounting for the cure, but also the additional, and no slight merit, of explaining in a reasonable manner what has not before been accounted for, namely, how it is that an interrupted galvanic current succeeds in producing contractions in these and similar cases after the continuous and faradic currents have failed.†

152. *Paralysis from central causes.*—The phenomena of paralysis, from lesions of the cranial or spinal centres, are of great interest, and accord well with our theory. We propose to consider them briefly.

As a rule, *in cerebral lesions,* the nutrition and contractility of muscles remain long unimpaired; and when wasting or atrophy occurs the explanation is to be found in the mere disuse of the limb.‡ This will be understood when we remember that although the muscle is paralyzed to the will, it is still in communication with the subordinate motor centres, between which and the muscle the normal molecular changes continue to pass.

Here electricity is powerless for good. "In direct proportion to the amount of contractility present is the uselessness of electricity. If the contractility [to electricity] be perfect, although the paralysis to the will be absolute, you can do nothing.‖

* See Dr. Russell's Lectures, etc., pp. 52, 54, etc. Drs. Beard and Rockwell, p. 299.
† Dr. J. Russell Reynolds, Lectures, etc., pp. 28, 29, 52, 54, 90, 91, etc. ‡ Dr. Bastian, Paral. from Brain Disease, p. 172. ‖ Dr. J. Russell Reynolds, Lectures, etc., p. 71.

153. *In spinal paralysis*, also, "If you find the contractility of a muscle good, your prognosis is bad, so far as electricity is concerned. If you find, for instance, a limb perfectly paralyzed, but contracting perfectly well to electricity, or sometimes even in excess, you can do nothing more by applying electricity to that limb."*

We see in both these cases, that where the nutrition is perfect, electricity is powerless to aid the paralysis. Why? Because the good effects of electricity are not for the nerve, or for nervous tissue, but for the muscle; and in these cases the muscular fibre is not in need of improvement, for it is already healthy. True, it does not respond to the will: but that is not the fault of the muscle, but of the brain lesion, which intercepts the impulse of the will in its passage to the muscle. Electricity does not act the part of a tonic or vitalizer to the diseased brain. The reason we assign for this is, that a portion of the nervous mass is paralyzed, and electricity, as an additional paralyzer of nerve tissue, would only add to the mischief.

154. *Electricity for diagnostic purposes.*—Electricity, however, is valuable in these cases for diagnostic purposes; because the greater or less degree of contractility of the muscle to electricity depends on the slight or severe character of the lesion, whether in the cranium or spine. When the damage is slight, the nerve and muscle will be only in a corresponding degree impaired, and contractility proportionately diminished. When the lesion and its degenerative effects are severe, the power of the muscle to respond may be abolished, as we shall see in the next paragraph.

155. *In spinal paralysis again.*—"If the muscular contractility [to electricity] in the paralyzed limb, be *entirely gone*, and show no sign of re-appearance, after five or six applications, your prognosis is bad . . . . it is useless to go on."†

Here, "the muscles derive nothing from the cord, because the latter is diseased or destroyed."‡ The molecular change in which nerve-force manifests itself, is so feeble that control over the muscle is being lost; and were the nutrition of the muscle not also proportionably impaired, it would become contracted. As electricity cannot here suspend nerve-force, because nerve-force is already at zero, so as to bring about muscular contraction, and with this action promote nutrition of the muscular fibres, (§ 148) and thereby restore power, it is powerless for good, as stated above.

156. Again, *in central lesion*,—"If the contractility of the muscle [to electricity] be *much diminished*, [without being lost] there is a good deal you may do." What this is, Dr. Reynolds proceeds to tell us. "You may restore, if it be lost, the *nutrition of the muscles*; you may bring back their bulk. If the limb be cool, as it very often is, from defective circulation, you may bring back the normal

* Dr. J. Russell Reynolds, Lectures on Clin uses, &c., p. 94. † Ibid, pp. 89, 91.
‡ Ibid, p. 88.

temperature. When the contractility has been defective, you bring that back to its normal state, and you find then that you have very much improved the relationship of that limb to the will of the individual,—that is, you *pro tanto* improve, or it may be entirely cure the paralysis."*

157. *To spinal paralysis*, also, the same remarks are applicable. "When you find *a certain amount of contractility*, there is a great deal to be done, and much room for hope" in the improved nutrition which may follow. "For example, the action of the fingers may be rendered less clumsy: the extensors of the foot and toe so far improved that the great toe drags less upon the ground in walking. You may call into exercise the muscles of the limb; you can improve their nutrition and their strength; and you may do something towards effecting a change in the nutrition of the cord itself."†

In these two last cases the nutrition of the nerve and muscle has evidently suffered; but not to the same extent as in the preceding one. The polarity of the molecules (§74) has not been entirely reversed. There is something that electricity may do in temporarily suspending what nerve-force remains; and so liberating the muscular contractile fibres. By rapid repetitions of contractions and relaxations (§148) in this way, blood and pabulum are attracted, and nutrition is improved; which, after all, "is the great object of electrical treatment."‡

158. *Early Rigidity.*—This is a state of the muscles which attends cerebral paralysis; and occurs in some cases "immediately after the commencement of the attack, whilst the patient is still in a state of apoplectic or epileptiform stupor. . . . . The lesion of the brain in these cases is often a large one, seriously implicating some extent of the cortical grey matter, and destroying a considerable area of the subjacent white substance."‖

This cortical, grey, or vesicular brain substance, is the originator of motor nerve-force; while the white, fibrous, or medullary tissue, is its conductor.§

How admirably our theory comes into play here! With a large lesion in the motor tract of the brain, causing motor paralysis, need we wonder that motor nerve-force is so enfeebled as to be no longer able to restrain the inherent contractility of the muscular fibre cells, which pass into a state of contraction thus early, partly from their complete liberation from nervous control, and partly from their contractile power being as yet unimpaired, as happens at a further stage.¶

Dr. Reynolds forbids electricity here, because "it may do harm."** Why, he does not say. Other electricians fix upon various times, ranging from a week to ten months, within which this mode of

* Dr. Reynolds, Lectures, pp. 78, 79. † Ibid, pp. 89, 91. ‡ Drs. Beard and Rockwell, Med. and Surg. Elec., 2nd Ed., p. 284. ‖ Dr. H. C. Bastian, Paral. from Brain Disease, p. 154. § Dr. Carpenter's Human Physiol., p. 742. ¶ Dr. Bastian. **Lectures, pp. 79, 80.

treatment may be attempted.* Of course there is the conventional supposed state of "irritation" pleaded as a bar to the use of a supposed "stimulant," like electricity. But Dr. Lincoln points out "the narrowness of the view that excludes a method of treatment because it is of the nature of a stimulant. Stimulants are not necessarily excluded in the treatment of apoplexy,—alcohol is not excluded."† We shall see, presently, that the "irritative" theory is a matter of doubt in "late rigidity;" if indeed it be not simply a legacy bequeathed to modern times from ancient theories long exploded.

We venture to attribute the danger of electricity in early rigidity to the already diseased condition of the nerve centres, and the consequently enfeebled condition of nerve-force, which can bear no further perturbation; and its uselessness, to the healthy contractile power of the muscle, which admits of no improvement.

159. *Late Rigidity.*—Dr. Todd originated the idea that this state of the muscle was due to the process of cicatrization of the brain lesion, and its supposed irritation of adjacent nerve tissue. Dr. Bastian thinks "there is much room to doubt" this theory; and that secondary changes in the spinal cord may have quite as much to do in producing it. "This latter view, and strong evidence in favor of it, have been forthcoming during the last few years."‡

Dr. Reynolds recommends faradization in this state. He says:—"In late rigidity you may apply it without fear, and with considerable advantage." But, then, it is best applied, *not to the seat of the disease, nor even to the implicated muscles, but to the antagonistic healthy ones*, with a view of helping them, by improving their nutrition, to resist the contracting tendency of those muscles whose motor nerves are paralyzed!‖ Not a word here about the "vitalizing" influence of electricity on the paralyzed nerve centres of the brain or cord! Indeed, every additional fact but confirms the truth of the general principle we have been discussing. By electrical treatment in paralysis, the muscles, including the sphincters, are simply sometimes kept from wasting or atrophy by a species of exercise, until the nerve lesion gets well, or the patient succumbs. "Only this and nothing more!"

Even this is something to be glad of. But it is unwise to claim for even a potent agent, more than it is really capable of accomplishing, as has been too much the rule with electricity.

160. *Electricity in nerve wounds.*—"M. Duchenne is of opinion that electricity has no real utility in traumatic nerve lesions until some months, or longer, have passed away, and there has thus been a chance for nerve repair. Until this time, he believes that its use does no good, and that atrophy and other changes go on whether it be employed or not."§

* Dr. Lincoln's Electro-Therapeutics, pp. 109, 110. † Ibid, p. 108. ‡ Paral. from Brain Disease, p. 156. ‖ Lec. on Clin. uses, &c., pp. 67, 80. § Drs. Mitchell, Morehouse, and Keen, Gunshot wounds, &c., p. 155.

This is, to say the least, very poor behaviour on the part of "nature's own tonic," and "vitalizer," as electricity is assumed to be. How is it to be accounted for on the popular theory? Will the ghost of defunct "irritability," once so potent under the tutelage of Brown and Broussais, be recalled from the Shades to do duty here? If so, let us hope that it will not be for long; but that more rational views will soon prevail.

As for our own theory, we have explained it very badly if the reader cannot make his own application of it here; and see in it a sufficient reason why electricity is useless in a nerve lesion.

161. *Another problem solved.*—It is highly creditable to any theory that it furnishes a reasonable explanation of certain phenomena, not otherwise accounted for: the fact that it does so renders the truth of such a theory highly probable. The previous pages contain instances of the kind here alluded to, some of which have heretofore remained unexplained problems in electro-therapeutics equally with the one now to be introduced. The arrangement adopted in treating of these, however, seemed most convenient.

Here is the problem :—"Why muscles that are paralyzed should act [that is contract] more readily than healthy muscles, to a slowly interrupted galvanic current, has not yet been explained?"*

There is here, indeed, a double problem of great interest.

1st. Why muscles, paralyzed to the will, should contract to electricity more readily than healthy muscles.

2nd. Why it is to a slowly interrupted galvanic current, rather than to a rapidly interrupted one of the same kind, or to the faradic current, this is due.

Let us consider these in order.

As to the first, the theory here advanced offers an easy and natural explanation. The situation is this :—

(*a*) The muscles possess an inherent power of contractility, and exert it in proportion as nervous influence is withdrawn.

(*b*) In the limb, paralyzed to the will, the muscles are to a greater or less degree, emancipated from nervous control, owing to a diseased state of the motor centres or nerves. Hence, in order to exert their power of contraction, the muscles have less resistance to overcome than have the muscles of the healthy limb, the nerves of the latter exercising normal restraining power.

(*c*) As a consequence, a mild paralyzing current of electricity suffices to extinguish the reduced restraining power of the weakened nerves of the paralyzed limb; but is too feeble to effect this in the healthy one.

As to the second part of the problem, its solution is to be deduced from the difference already shewn to exist between the instantaneous flashes of the quickly interrupted current, either galvanic or faradic,

* Dr. J. Russell Reynolds, Lect. on Clin. uses of Elec., p. 98.

and the intenser effects produced by the longer electric throbs of the *slowly* interrupted galvanic current. (See § 140.)

Either of the former fails sufficiently to suspend molecular polarity in the nerve, which we have seen, (§79) exhibits a tendency to fixedness or stability. But the more prolonged and more intense effects of the slowly interrupted galvanic current reach every molecule and effectually paralyze the action of the nerve, so that if a flicker of muscular contractile power exists, it has full scope to display itself in a degree corresponding to its strength.

Another reason, doubtless, is to be found in the fact, that a slowly interrupted current is less irritating to the skin, and for this reason a stronger current can be borne than with rapid interruption.* Hence a more intense action, and a higher degree of paralysis is here possible.

162. *Electricity in spasmodic states.*—Why is it that electricity has proved of so little benefit in the treatment of spasmodic diseases?

We shall show that the assertion implied in this query is true; and it will be evident that the fact of the failure of electricity in these cases accords well with our general theory.

For if spasms and irregular muscular contractions be due to a withdrawal of nervous influence from the implicated muscles (§87) the use of an agent whose prime quality is to still further paralyze motor nerve-force could not be expected to prove beneficial. Nor has it been. Drs. Beard and Rockwell have not a single case of cure to offer, and dismiss the subject in a cursory manner, with the remark that "the prognosis is unfavourable for all except rheumatic cases."† Nor is their outlook for tetanus and other varieties of spasmodic contractions any more hopeful.‡ The same may be said of chorea;‖ of which Dr. J. R. Reynolds writes, "the less one says about chorea, and its treatment by electricity, the better it will be for therapeutic science."§

Now, if spasms and irregular muscular contractions are due to a *depressed* state of the nervous centres, and electricity were a *stimulus* or *tonic*, its good effects ought to be more marked. If spasms or irregular muscular contractions were due to an *excited* or functionally exalted condition of the nervous centres, and electricity were a *sedative*, its good effects ought to be more apparent.

And if electricity be *both a stimulant and a sedative*—as has been claimed for it,¶—on either hypothesis as to the state of the nervous centres, it should have deserved a more favorable record.

We have heretofore shown on authority that is unquestionable, that spasm, convulsion, tremor, &c., depend on a depressed state of the nervous centres; that electricity paralyzes those centres; and

* Drs. Beard and Rockwell, Med. and Surg. Elec., 2nd Ed., p. 330. †2nd Ed., p. 555. ‡p. 557. ‖p. 604. §Lec. on Clin. Uses, pp. 83, 102. Dr. Moritz Meyer is in accord with the same views. Elec. in Prac. Med. (Hammond) p. 349. ¶Drs. Beard and Rockwell, loc. cit., pp. 270, 459.

hence we account for its failure to cure a condition of the nervous apparatus which, primarily, it is calculated rather to aggravate.

163. *The case closed.*—In order not to unduly extend these pages, the foregoing imperfect exposition of the theory here propounded must suffice for the present so far as this part of the subject is concerned. If we have not noticed all the objections which may be presented to these views, we have done so with those which appeared most prominent and most difficult of solution, and we are not aware of having passed over any of importance.

If we were to attempt to sum up the conclusions at which we have arrived, from what is advanced in the previous pages, we could hardly do so more succinctly than they are to be found in the "general principle" with which we set out, and to which, if the reader desires, he may turn.

APPLICATION OF ELECTRICITY IN DISEASE.

164. Having said so much in reference to the mode of action of electricity, it may be expected that we should add a few words as to its practical application in diseased states. It is unnecessary to do this at any length; partly because, we think, the general indication for the use of this agent will be obvious from the views expressed of its mode of action in the preceding pages, and partly because to write at length on this subject was no part of our original intention.

165. It is well to understand that in the use of the two kinds of electricity we have referred to, which may be called *current* electricity, the quantity of electricity in the body, or limb, subjected to this kind of treatment is not necessarily increased. Nor is the body, or a portion of it, "charged" with a positive or negative electricity, as is the case when "static," "franklinic" or "frictional" electricity is transferred to it by means of a Leyden jar.*

The kind of electricity last mentioned is sometimes useful for medical purposes; but for various reasons it is seldom used.

166. It also appears to be a fact that the difference between the poles is more depending on the chemical effects they produce than on any differential quality in the current itself. Thus oxygen and acids accumulate at the positive pole and alkalies at the negative; and on the chemical or physical effects thus produced in the tissues, the phenomena of analectrotonus and catalectrotonus respectively are believed to depend.† For the same reason the local irritation of the skin, caused by the passage of the current, is less severely felt at the positive than at the negative pole.

This circumstance has given rise to the idea that the positive pole is best applied to the seat of pain if the pain be attended by a con-

* Drs. Beard and Rockwell, 2nd Ed., p. 86. †Ibid, p. 115.

gested or irritated condition of the parts affected, and the negative to some indifferent part. The reverse, however, applies to painful states depending on anæmia or malnutrition, where it is desirable to attract blood and pabulum to the seat of the disorder, as sometimes occurs in the complex forms of "spinal irritation." To these the negative pole is to be applied accordingly.

It is often difficult to determine which of these opposite conditions prevails in a given case, since many of the symptoms may be present in both these states, and hence a good deal is necessarily left,—here as elsewhere,—to the tact, judgment and experience of the physician. This fact shows the impossibility of laymen treating themselves successfully by electricity, any more than by other means of medication.

Fortunately, in many cases of neuralgia it makes no difference where the poles are placed relatively to each other, or in what direction the current is passed, provided it is made to traverse the implicated nerves so as to bring these under its influence.*

167. *The galvanic current.*—What is especially necessary to remember in reference to this current is, that where it is desired to utilize its paralyzing power for the relief of painful or irritated nerves, the poles or electrodes ought to be stationary, and the current not only continuous but *constant, i. e.,* not subject to variations of intensity as it may be from defects in the battery and other causes.

The alteration in the effects of this current, when interrupted, as by simply moving the electrodes while still in contact with the body of the patient, has been pointed out (§140) and is deserving of serious attention.

When it is desired to utilize the galvanic current to invoke muscular contraction in cases of loss of function of muscle, as from disuse, it ought to be interrupted; and the slowly interrupted current is more potent for this purpose than when the interruptions are rapid, for the reasons assigned. (§140.)

In morbid states, either primary or reflex, where it is desired to benumb the nervous centres, or their leading trunks, care must be taken to begin with the minimum strength of current,—if necessary to be cautiously increased,—otherwise serious results may follow. Among these are dizziness or syncope, from vaso-motor nerve paralysis, permitting undue contraction of the vessels of the brain, (see chapter on vaso-moter nerve innervation) indefinable nervousness, and, in one case, total blindness from paralysis of the optic nerve.†

168. *General applications* may be made by so placing the sponge electrodes as to include between them the painful part. The current by preference should be passed in the direction of the implicated nerves and not across them. The head, face and neck

* Dr. J. R. Reynolds, Lec. on Clin. Uses, p. 18. Dr. Anstie, Neuralgia, p. 257.
† Drs. Beard and Rockwell, 2nd Ed., p. 640.

are most susceptible to electric influence and the back and genitals least so. The strength of the current should be modified accordingly. Short sittings of a few minutes suffice, otherwise the paralyzing action on the nerves may be greater than is desirable.

169. *To galvanize the head.*—Place the poles at the forehead and occiput, or one on each ear, or mastoid process, &c., as one or other portion of the cranial mass is desired to be brought under the influence of the current.

170. *To galvanize the cervical sympathetic.*—One (small) electrode is to be placed in the auriculo-maxillary fossa, just behind the angle of the jaw. The other may be placed over the sixth or seventh cervical vertebra, in the depression just above the sternum, or by the side of the sterno-cleido-mastoid muscle.*

It is to be remembered that when galvanism is thus applied, the current and its effects are not limited to the sympathetic nerve, but also to a greater or less degree affects also the spine, "the depressor, the vagus, the phrenic and various branches of the cervical plexus, if not that plexus itself."†

171. The application of a paralyzing agent to these great nerve trunks may be justifiable and beneficial in certain painful or irritated states which they may influence, directly or by reflex action. It must be seen how very dangerous a proceeding it is in cases of chloroform narcosis, or of asphyxia from drowning or other cause, and how very readily the flickering lamp of life may be extinguished by a process of further paralyzing organic nerves, whose functional activity is already well-nigh extinct.

Drs. Beard and Rockwell record an instance of the danger thus incurred and of the fatal consequences in a case of opium poisoning:—"Under ordinary methods the patient was recovering, but in order to expedite the progress faradization was tried. One pole was placed on the ribs and the other somewhere on the neck, in order to find the phrenic nerve. Immediately the patient ceased to breathe, and no further treatment availed to rescue her."‡

The "instantaneous death of the patient" is attributed by these gentlemen to the employment of electricity, and in this case to the faradic current. The use of the galvanic current, especially if interrupted, would be still more dangerous in asphyxia, narcosis or paralytic "stroke."

Dr. Ringer writes as follows on a cognate part of this subject:—"It is a question of importance whether galvanism should be used in danger from chloroform. The committee appointed by the Medical and Chirurgical Society are of opinion that this agent is useful, but that it is far inferior to artificial respiration; but *some authorities are wholly opposed to its use, on the score of its influence to*

* Drs. Beard and Rockwell, 2nd Ed., pp. 372, 3, † Dr. Lincoln's Electro-Therapeutics, pp. 130, 1. ‡ Drs. Beard and Rockwell, 2nd Ed., p. 640. ‖ Med. and Surg. Elec., 2nd Ed., p. 665.

*arrest a very feebly beating heart, and so diminish any slight hope of recovery."**

172. *The Faradic current.*—Besides the general utility of this current for the *improvement of nutrition*, so often referred to in the preceding pages, it will often be found effectual for the *relief of certain kinds of pain.*

When used for this purpose, a fine, rapidly interrupted current should be employed. The more perfect is this quality, and the nearer it thus approaches to the continuous current, the more efficacious it will be found for this purpose. Here the milder paralyzing effects are indicated, without producing so intense an action as to call forth muscular contraction, or if so, only slightly : since this, in irritated conditions of the tissues, would only aggravate the pain. On the contrary, a coarser or more slowly interrupted current may be employed in preference, when muscular nutrition is chiefly desired : as in the class of cases where passive exercise, kneading, &c., are called for.

173. *General Faradization.*—A very effectual method of using faradization for general purposes, and which has borne the test of experience, is to place the patient seated on a large sponge, wet with warm water, and connected with the negative pole introduced beneath the chair, or stool. The positive pole, also armed with a warm, moist sponge, is then to be stroked over the thoracic, lumbar, and abdominal portions of the body, in the direction of the long axis of their muscles.

The current should be of sufficient strength to cause these moderately to contract, but not to cause painful irritation of the skin. As in doing this the operator is benefiting the muscles at the expense, so to speak, of the nerves which control them, the process must not be long continued : or else lassitude, exhaustion and other effects may be induced, and proportionately defeat the end in view.

The lower extremities may be treated in the same way, under similar precautions, with the negative sponge placed at the feet.

All this necessarily involves considerable labor and time on the part of the practitioner, and sometimes no slight inconvenience to the patient, who ought not, and need not, be much, if at all, exposed in person. When evident good is to be accomplished these drawbacks can and will, of course, be borne.

Conjoined with other suitable treatment, and the hygienic accompaniments of good air, suitable exercise and a proper dietary, many otherwise incurable cases may, by this means, undoubtedly be cured or relieved. Many disappointments, too, will be encountered ; but these are inevitable under any mode of treatment.

174. It is in those morbid conditions where the entire muscular system is badly nourished, and the functions generally are more or less impaired, as in the state known as general debility, and in

* Therapeutics, p. 291-2.

dyspepsia, constipation, amenorrhœa, spermatorrhœa, &c., depending on diminished local nutrition, or lessened functional activity of parts into which muscular fibre largely enters, that most good is to be expected from faradization or any form of electrical treatment.

So many local affections, however, are dependent upon, or associated with a lowered condition of the functions generally, that in many cases mere local applications will not suffice, and general faradization aided by other measures, medicinal, hygienic, and dietetic, will be necessary to promote a return to the normally healthy state.

175. As an example of its local use, in otherwise healthy states of the system, its effect on the mammary gland of a nursing woman in restoring the lacteal supply, when deficient, is very marked, and will often follow a few daily applications. This result is to be explained on the general principles already discussed, in accordance with which faradization promotes local attraction of blood, and with it increased pabulum, and consequently augmented functional activity. (§ 148.)

176. Its effect on the parturient uterus, too, is worthy of special mention. In the so-called atonic states of that organ, when the flabby muscular walls have their contractile power unduly restrained by spinal motor nerve-power, the faradic current, by suspending the influence of the latter, enables the weak muscular tissue to put forth increased activity. (See chapter on ergot of rye.)

In this way, electricity may prove not only a useful adjunct to ergot, but even a valuable substitute. Powerful contractions may be induced in many cases, with the advantage that the effect can be regulated or suspended at will; which is not the case with ergot when once administered. The contractions, too, can be rendered intermittent, with obvious advantage over the persistent expulsive efforts produced by ergot.

To employ faradization for this purpose, one pole may be applied to the fundus, and the other to the os uteri; thus acting on the intra-muscular nervous filaments, or directly through the spinal nerves, one sponge being applied to the back and the other over the uterus, in front.

177. As this reference to the therapeutic uses of electricity is merely an incidental one in our general purpose, the leading principles here laid down must suffice. We have not undertaken to write a treatise on electricity; and the student will find in the elaborate volumes now before the public such additional details for his guidance as he may deem necessary.

CHAPTER V.

ACTION OF ERGOT OF RYE.

178. *Fourth general principle.*—The contractions induced, more especially in unstriped muscular fibre, by ergot of rye, follow the same rule, or law, as irregular muscular contractions, otherwise occurring; that is to say, they depend on the withdrawal of nerve-force, and the cessation of its ordinary restraint upon the contractility of muscular fibre, which, being thus left free to act, passes into a state of contraction.

179. Unstriped, or involuntary muscles, are not subject to the influence of the will. Tissue of this kind constitutes the double layer investing the alimentary canal. It also forms the muscular coat of the bladder, uterus, dartos, bronchial tubes, of all the large excretory ducts, of the middle coat of the blood vessels, and even furnishes some fibres to aid in promoting the contractility of the skin.*

180. The nervous supply to this unstriped muscular fibre is chiefly derived from the sympathetic system, especially in the abdominal viscera; and this is true both of sensory and motor innervation. But the purely sympathetic, or gelatinous nerve fibres are accompanied throughout their course by tubular fibres from the cranio-spinal system, as they pass to their points of distribution.†

181. There are two peculiarities of this kind of muscular fibre worthy of mention. 1st, The slowness or apparent sluggishness with which it contracts under the influence of so-called "stimuli," compared with the striped variety; and 2nd, a very striking peculiarity, consisting in the rhythmical nature of the movements of parts consisting wholly or in part of this kind of fibre, deriving its nervous supply from the sympathetic, of which the movements of the heart and intestines are good examples.‡

With the exception of these differences, unstriped, or involuntary, muscular fibre seems to be subject to the other general conditions which govern the striped, or voluntary, muscular fibres.

182. Ergot of rye is one of those substances which, in a marked manner, produces contractions of non-striated muscular fibre, wherever this tissue is to be found in the body.‖ Hence, under its influence, the calibre of the minute arteries is every where reduced; and, as a consequence, it is extensively used in controlling hœmorrhage, not only from the uterus but from the lungs, nose, &c., and for

* Drs. Todd and Bowman, Phys. Anat., pp. 155-6. †Ibid, p. 500. ‡Drs. Todd and Bowman, Path. Anat., p. 509. ‖Dr. Ronayne, Braith. Retros., July, 1870, p. 199; and ditto, Dr. Lane, January, 1875, p. 174.

the same reason is recommended by Dr. W. A. Hammond, in spinal congestion, as an important agent in the treatment of that state.

That it produces this effect—contraction of the vessels—has been demonstrated by Dr. Hammond, under the microscope, in the capillaries of a frog's foot.*

Its remarkable effect on the gravid uterus is well known. In this it resembles the action of electricity, as we have already shewn, and we see no reason to doubt that its mode of action is similar also.

We have had evidence that narcotics, as well as electricity, paralyze the nerves and thereby cause convulsions and spasms of muscular fibre. Dr. Pereira assures us that the poisonous effects of ergot are similar to those of other narcotics,† and like them, produce spasms and convulsion. Have we, then, any right to regard the contractions of ergot as produced in an exceptional manner to the similar effects of other drugs, or to those of electricity?

183. If we had not been accustomed to regard ergot as a stimulant to muscular fibre, could we readily believe that an agent which produces such effects as dizziness, giddiness, faintness, feeble slow pulse, dilated pupils, pallid face, paralysis, gangrene, imbecility, delirium, coma and insensibility, tetanic spasms, convulsions and death,‡ was really a stimulant?

Dr. Anstie has shewn that other drugs which produce symptoms similar to these, including alcohol, are in every degree of their operation, after physiological effects begin, simply narcotics; and that the very essence of a narcotic is that "it paralyzes, to a certain extent, the nervous system."‖

Perhaps, therefore, the thesis we have laid down, that ergot is purely a paralyzer of nerve-force, and that it is through this effect of its action it brings about the contraction of muscular fibre, may, on consideration, not seem so startling or absurd as when first presented.

Let us examine the facts and see how far they agree with this hypothesis.

184. That various vital processes are not so dependent on the influence of the nervous system as may sometimes be taken for granted, will appear from the following considerations:—In the embryo, the "action of the heart commences when as yet its contractile parietes consist but in an assemblage of ordinary looking cells; no proper muscular tissue being evolved, and no nervous system being as yet developed from which the stimulus to movement can proceed; and it is impossible to assign any other cause for the movement under such circumstances, than the attributes *inherent in the tissues* which perform it." So again, . . . "the parturient action of the uterus cannot be fairly attributed to any of

*Diseases of Nervous System, p. 393. Dr. Sidney Ringer's Therapeutics, p. 509.
†Mat. Med., Vol. II, pp. 139, 140. ‡Ibid, pp. 139, 140. ‖Stim. and Narcot., pp. 214, 244.

the agencies which have been supposed to excite it; but must be looked upon as one of those phenomena whose periodical recurrence is due to the regularity of the operations of its growth, whereby the tissue attains its maturity in a certain limited time and then discharges itself of its vital force in the shape of motor power."*

Again, in reference to uterine contractions in parturition, the same eminent author states:—"There is no proof whatever that these changes are dependent upon nervous influence: in fact there is much evidence that the parturient action of the uterus is *not* the result, as some have maintained it to be, of a reflex action of the spinal cord, but *is due to its inherent contractility;* for numerous instances have occurred in which normal parturition has taken place, notwithstanding the destruction of the lower part of the cord, or the existence of a complete state of paraplegia, which marked its functional inactivity; and the continuance of the peristaltic action for some time after somatic death, when neither the cerebro-spinal nor the sympathetic system can afford any supply of nervous power, is yet a more satisfactory proof of the same position."† Thus, again, "The *post mortem* contraction of the parturient uterus, to such an extent as to expel the fœtus, of which the patient had died undelivered, is a phenomenon several times recorded; and Dr. Robert Lee has witnessed one remarkable case, in which, the patient having died suddenly from rupture of the uterus and escape of the fœtus into the abdominal cavity, the uterus was found, when an examination was made twenty-four hours after death, to be completely inverted."‡

Now, having seen that the entire process of parturition may be completed without the aid of the nervous system; and that the action of ergot and that of electricity are similar in both producing uterine and other muscular contractions: and having seen in the foregoing pages, that the state of spasm and contraction of muscular fibre implies the withdrawal of nervous influence, can we suppose that the state of spasm, contraction or convulsion produced by ergot, differs in any important degree as to the mode of its production, from the spasms of electricity, or from the spasms and contractions of muscular fibre otherwise occurring, as by the effects of drugs, disease or injury? And if spasms and muscular contractions, generally, obey a uniform rule or law as to their causation, then we must conclude that the spasms of ergot are not exceptional in this respect; but that they, too, depend upon a paralyzing influence on motor and vaso-motor nerves, leaving muscular contractility free to assert itself, alike in the case of muscle, artery and uterus.

185. It may be objected, that the contraction of the uterus in parturition is a normal, and therefore a natural act, and so far differs from spasmodic contractions of an irregular kind, induced by drugs,

* Dr. Carpenter, Human Physiol., p. 131. †Dr. Carpenter's Human Physiology, pp. 979, 980. See also note, p. 982. ‡Dr. Tyler Smith—Dr. Carpenter's Human Phys., p. 334.

injury or disease. The rhythmical actions of the heart and intestines, too, are natural movements, but it is well known that these can be much assisted, increased or retarded by modifying the conditions on which they depend, by the extraneous influences mentioned. And when so modified, by drugs, injury or disease, these viscera, including the uterus, are not the less fulfilling the possibilities of their condition in obedience to their natural law. That is to say, if circumstances favor increased action this result takes place; and the very extremity to which they may be driven, in their several functional activities, even to the peril of the life of the organism, is simply their attempt to obey the law of their physical life under physical difficulties and impediments. So that if ergot paralyze the nerves which ordinarily exert a restraining influence over uterine contraction, and that viscus contract more vigorously as a consequence, this action, on its part, is as normal and natural as a more moderate contraction would be under less favorable circumstances.

Do we then mean to imply that a first step towards normal parturition is the paralysis by a natural process of the spinal nerves supplied to the uterus, in order thereby to facilitate uterine contraction? Not at all! When the time arrives for the uterus to discharge, in the shape of motor power, the nerve-force it has long been accumulating, (Dr. Carpenter) it will have to resist and overcome the restraint normally exercised over its contractile power by the inhibitory spinal nerves; and under favorable circumstances will be fully able to accomplish this by its own inherent contractility.

186. We have been asked, if this theory were true, how does opium, so frequently administered for excessive "after pains," produce its effect? It is said its influence cannot be directed to moderate the action of the spinal nerves since contraction is independent of these; nor can it influence the muscular contractility of the uterine walls, which is said to be, if not a non-vital property, at least not amenable to ordinary influences transpiring in the system.

The answer is easy. Opium does not act through the *motor* spinal nerves in these cases, for the relief of pain, nor does it arrest the contractile tendency of the uterus, which it often greatly helps. But it partially paralyzes the sensitive nerve fibrils and so prevents the sensation of pain occasioned by pressure on these during the act of contraction, from being felt.

It is well known that a dose or two of opium, given perhaps to relieve "false pains," or otherwise, proves an excellent parturifacient and greatly accelerates labour. How? By partially benumbing the motor spinal nerves, arresting their restraining function over the uterine muscle, which, free from restraint, passes as promptly as possible into a state of contraction.

Quinine has a similar effect, and doubtless also a similar mode of action, for it, too, is a narcotic* and induces a state of contraction in muscular fibre.

187. Perhaps one cause of abortion may be found in the very want of tone and power on the part of the spinal nerves; in consequence of the deficiency of which, they are unable to restrain uterine contraction until the proper period arrives for its exertion. As a consequence of this predominance of uterine contractile power, the fœtus may be prematurely expelled. If such a diagnosis were made, as perhaps might often be the case, the indications for treatment would be obviously such as would improve nervous tone generally and that of the spinal nerves particularly.

188. Again, it may be objected, that the suggestion of a paralyzing action on motor nerves, in the case of ergot, and also in the case of electricity, is too alarming, and the possible effects too serious to think of approvingly, considering how frequently it is resorted to.

In reply, we ask if it is believed that spasms, convulsions, &c., are caused by an excited or over-active condition of the nervous centres, is not the proposal to *stimulate* these nervous tracts equally portentous? Doubtless it would be so thought, had the suggestion been presented to us for the first time, and especially so if our ideas on the subject had previously been of an opposite kind. And yet there is abundant proof—already referred to—that stimulants are among the most potent and effectual remedies for just such states.

But, as a matter of fact, our leading physiologists, and others, have long since familiarized us with the idea that certain very innocent phenomena have their dependence on paralysis of a portion of the nervous system, and that, no other than the great nerve of organic life. Thus, flushing after a hearty meal, or from a glass or two of spirits; the similar effect which in some cases attends the use of chloral hydrate; or, as is mentioned by a grave authority, in some instances from "sitting with the back to the fire;" nay, even the modest blush which "mantles cheek and brow" of innocent maidenhood, are all explained as the result of paralysis of the vaso-motor branches of the great sympathetic, which, as a consequence, permits dilatation of the blood vessels, the calibre of which these nerves are known normally to control.†

The same explanation, paralysis of the sympathetic, is given, on authority, for the flushing and temporary vascular fullness produced by the nitrite of amyl; and in this instance it is the vaso-motor centre itself, in or near the medulla oblongata, which is assumed to be paralyzed; although a single whiff from an uncorked

* Dr. J. H. Bennett's Clin. Lec., p. 879. † Dr. J. Crichton Browne, London Lancet, April 1, 1871, p. 40. Braith. Retros., July, 1871, p. 233.

bottle containing the drug, will suffice for this purpose. Yet use is being made of this powerful paralyzer in appropriate cases.*

We need not, therefore, abjure a useful medicinal agent, because it is a paralyzer, any more than another, which we call an excitor, of a part of the nervous system. Nor should we, as a matter of prudence and consistency, continue to exert a paralyzing influence under the name of stimulation.

189. The number of the diseases for which ergot has, of late, been found beneficial, stamp it as one of the most remarkable of drugs. Besides its well-known effects on the gravid uterus, it is now extensively prescribed, or highly recommended, in hæmoptysis, hæmaturia, purpura, aneurism, spinal congestion, congestive headache, migraine, neuralgia, herpes zoster, sciatica, tic douloureaux, hemicrania, dysentery, spermatorrhœa, bronchocele, menorrhagia, gleet, &c. References to medical authorities illustrating its value in these several conditions are before us, but we omit them on account of their collective number.

Ergot in Diabetes.—Ergot of rye ought to be of value in the early stages of diabetes for the following reasons:—

1st. The intimate association of the chief vaso-motor centre with that part of the medulla oblongata corresponding to the 4th ventricle, puncture of the floor of which has been shewn by Bernard to produce saccharine urine.

2nd. The fact shewn by Dr. W. H. Dickinson that in diabetes the arteries of the encephalon and spinal cord are unduly dilated, with a consequent thinning of their walls and extravasation into the contiguous nervous matter, resulting in its degeneration.† Bernard found a similarly dilated condition of the blood vessels of the liver in diabetes.

3rd. The vaso-motor centres or nerves are evidently implicated in this dilated state of the arteries, and ergot is one of the remedies which brings about vascular contraction, and by so doing prevents its consequences.

4th. As a matter of fact, it is remedies which produce similar arterial contraction,—as opium, ipecacuanha, dover's powder, nitric acid, &c.,—which have been proved to exercise most control over this disease; and ergot is still more effectual for securing the desired vascular contraction.

Acting on these premises, the writer has ventured to prescribe ergot in a case of chronic diabetes, with some favorable results. But it is not to be expected that after several months or years of dilatation of arteries, extravasation of their contents and degeneration of the adjacent structures, any remedy can display a marked success. To be effectual the remedy ought to be administered in

* Dr. S. Ringer's Therapeutics, pp. 311, &c. † Braith. Retrospect, July, 1871, p. 105. Med. Chir. Trans., 1870, p. 251.

suitable doses, in the earliest stage of the disease, before organic changes have occurred.

190. Ergot has proved useful in these several widely different diseases, when the morbid state resulted from an unduly dilated condition of the blood vessels; or when it was such as to be remedied by bringing about the opposite condition, that of vascular contraction. From the considerations heretofore advanced, we think there is reason to believe that ergot does this by paralyzing the vaso-motor nerves, whose function appears to be to *dilate* the blood vessels, thus permitting the muscular fibres in the vascular walls to fulfil their normal law of contraction; reducing the calibre of the vessels, diminishing the circulation of blood, and thus curing or relieving congestive states of tissues or organs.

The whole question of vaso-motor innervation herein involved, will be discussed in our next chapter.

CHAPTER VI.

VASO-MOTOR NERVE-FORCE IN ITS RELATIONS TO THE BLOOD VESSELS.

191. *Fifth general principle.*—The muscular fibres of the middle coat of the arteries, in the normal state, tend continually to exert their inherent contractile power in lessening the calibre of these vessels, and so diminishing blood supply: while the vaso-motor nerves, ramifying among these muscular fibres, have for their function the restraining of this contractile power; and, when predominant, aided by blood pressure, induce dilatation of the blood vessels, with correspondingly increased vascular activity.

192. The mechanism, so to speak, by which the calibre of the arteries is diminished or enlarged, so as to regulate the vascular supply to parts and organs of the body, is a problem of great interest in physiology, and of great importance in therapeutics; since to the modifying of this mechanism, a large class of our remedies are mainly directed, with a result of not merely controlling the extremes of vascular contraction or dilatation, but of remedying the consequences which result from these states.

193. That the muscular middle coat of the arteries *is* endowed with an inherent power of contractility, is not for a moment questionable. Physiological authorities are too explicit on this point to render any elaborate proofs of the fact necessary. But for the convenience of the reader, we quote as follows. Messrs. Todd and Bowman say:—"The demonstration of these fibres in the walls of the arteries, by the microscope, leaves no more doubt of the existence

of a muscular contractile force in them, than of its existence in the œsophagus and intestines. . . . From the combined experience of anatomy and experiments, it can no longer be doubted that arteries possess *an inherent contractility*, in virtue of the presence of unstriped muscular fibres in their tissues. . . . . It is owing to the resistance offered by this contractile power of arteries to the passage of fluid in them that the anatomist will fail to inject the tissue completely, if he attempts it too soon after death."*

Thus, here, as elsewhere, this power survives the extinction of vital force generally, as is well seen in the empty and collapsed condition of the arteries after death.†

"The arteries owe their contractility to the unstriped muscular fibres which they contain. These fibres shorten under the influence of impressions conveyed to them by the vascular nerves, which nerves, together with the automatic centre from which they radiate, constitute the vaso-motor nervous system."‡

Such is the accepted and orthodox theory, that "these fibres shorten" under a nervous stimulus, &c.; but it is the object of the following pages to shew that these fibres shorten from their own inherent contractility, and that what the nervous "influence," "impression," or "stimulus" really does is to relax them, and, aided by blood pressure, to dilate the arteries. We are prepared with a strong array of facts in support of this view, and shall present them with such force and cogency as we can.

194. Physiologists are agreed that it is through the agency of the sympathetic nervous system that the calibre of the blood vessels is regulated; and they are equally agreed that it is through the *excitation* of the vaso-motor, or vascular, nerves of that system, that the calibre of the arteries is *contracted* and vascular activity diminished.‖

It is in regard to the mechanism by which *dilatation* of the blood vessels, especially the arteries, is effected, that much difference of opinion has existed, and numerous theories have been propounded.

It has been customary to attribute arterial dilatation in part to *paralysis* of the vaso-motor nerves, in consequence of which, it is alleged, the arterial walls are relaxed, permitting passive dilatation; and in part to increased "suction power of the capillaries," owing to increased rapidity of nutritive changes in the adjacent tissues.§

But it is admitted by physiologists that a mere passive relaxation of the arterial walls does not sufficiently account for all the phenomena of vaso-motor innervation, and notably so for what is seen to occur in Bernard's experiment on the nerves or the sub-maxillary gland,¶ to be referred to hereafter. (§ 211.).

* Pathol. Anat., pp. 682, 683. † Dr. Carpenter's Human Physiology, pp. 485, 492. ‡ Dr. Burdon-Sanderson, Hand-book for the Physiol. Laborat., p. 244. ‖ Dr. Carpenter's Human Physiol., pp. 486, 830. Dr. Beale, Disease Germs, p. 330. Dr. Burdon-Sanderson, Hand-book Physiol. Labor., &c., p. 244. § Dr. Brown-Sequard, Lectures, &c., p. 143. ¶ Dr. Anstie, Neuralgia, pp. 192, 195.

Accordingly, some physiologists have hinted at the idea of *active dilatation;* and inferences from certain facts have been drawn, with a view of establishing the existence of two antagonizing sets of nerves, one, cerebro-spinal, for dilating the arteries, and the other sympathetic, for contracting them. It was never attempted to be shewn how these antagonistic nerves were connected with the necessary muscular fibres for contracting or dilating purposes; or demonstrated that more than one set of such nerves existed, or could exist, under the circumstances, so that the proposal has been discountenanced as "wildly improbable."*

195. The vaso-motor theory, which has found most favor, and which is now generally accepted by physiologists, is, that the sympathetic vascular nerves, when excited, contract the arteries, but that the power of these nerves is at times held in restraint, or "inhibited" by another set of nerves, which act, not on the muscular walls of the arteries, but on the ganglia of the contracting nerves; placing an embargo, or "break" upon them, as it were, and so favoring vascular dilating power. Accordingly, drugs, as nitrite of amyl, which cause flushing and vascular fullness, are said to paralyze the vaso-motor nerves: or to excite the "inhibitory" vascular nerves, which antagonize the former.

The following schema, embodying this theory, is from a recent publication.†

"I. Ganglia in the walls of the capillaries, or about them, regulating their calibre.

"II. Spinal vaso-constrictor fibres, going to the muscle in the arterial walls.

"III. Spinal nerve fibres, inhibiting the peripheral vascular ganglia, vaso-dilator fibres.

"IV. Inhibitory fibres from the skin to the vascular ganglia in their vicinity."

196. We shall have something to say presently in regard to this very complicated vaso-motor system of nerves, and their assumed inhibitory antagonists. The entire present vaso-motor system is based not so much on certain *facts,* as upon the interpretation put upon certain *acts;* such as the section of a nerve or ganglion, and the manner in which this affects the blood vessels whose walls are supplied by it. We have to suggest that the acts in question admit of a very different explanation to that ordinarily given, while the effects remain unchallenged.

In order to show that an interpretation of certain experiments, other than has been given, is possible and probable, the nature of the parts acted on, the experiments performed, and the results, must be passed in review. This we shall do as concisely as possible.

*Dr. Anstie, Neuralgia, p. 192. †Dr. Ott's Action of Medicines, Lindsay & Blakiston, 1878. This author quotes Huizinga, Pfluger's Archiv., Vol. XI., p. 207. Bowditch, Boston Med. Jour., July, 1877.

As we have to deal with both the cranio-spinal and sympathetic nervous systems, the peculiar arrangement of each must be taken into account.

197. *The cranio-spinal nerve centres*, or ganglia, are arranged on the principle of centralization of power, so to speak, *i. e.*, they are placed together in direct continuity. Their relationship to distant parts of the body is maintained by nerve-trunks, or cords, which convey sensitive impressions to, or motor impulses from, these centres. Hence, the section of these nerve cords necessarily cuts off communication, or the transmission of impulses, between these centres and the peripheral parts or tissues of the body, to which these nerves are distributed.

198. *The sympathetic nerve*, as it is called, may by comparison, be said to have its numerous ganglia arranged on the principle of decentralization; scattered as its centres of power,—ganglia,—are, throughout the trunk of the body, neck and head, each presiding over its own little dependency, and regulating for itself, under subordination to a higher centre, the special functions allotted to its charge.*

Three kinds of nerves enter into the formation of these ganglia: namely, sensitive and motor (tubular) fibres, and the grey or gelatinous tissue which specially distinguishes the sympathetic.†

There are four of these sympathetic ganglia in the head, including the adjacent sub-maxillary ganglion. There are two, sometimes three, in the neck, on each side, one above the other. The heart has its own special ganglia, and there is a long series in the thorax, on each side of the spinal column in front, besides numerous others in the lumbar and sacral regions, and among the viscera: all of which are connected together by cords of communication which are not mere nerves, but are true expansions of the ganglia in a cord-like form.‡

The four sympathetic ganglia of the head, besides their connections with the superior cervical sympathetic, also receive filaments which ascend the cervical part of the spinal cord, to animate the iris, and assist in supplying their peculiar influence to the blood vessels of various parts of the head.‖

In addition to all this, we have the supreme executive, or chief vaso-motor centre, which, whether located in the pons varolii, (Dr. Bastian) or medulla oblongata, is by some physiologists believed to be inter-cranial;§ though by others, subordinate centres are believed to exist in the spinal cord.

*Dr. Maudsley, Phys. and Pathol. of the Mind. †Drs. Todd and Bowman, Path. Anat., p. 506. Dr. Meryon, Functions of the Sympathetic, &c., pp. 5, 41. ‡Drs. Todd and Bowman, Phys. Anat., pp. 499, 502, 503. ‖Dr. Brown-Sequard, Lectures, Phys. and Path., Cent. Nerv. Syst., p. 144. §Dr. Burdon-Sanderson, Hand-book for the Phys. Labor., p. 244.

199. *Experiment on the cervical sympathetic nerve.*—It was shewn by Dr. Brown-Sequard and M. Claude Bernard (1851-2) that section of the superior cervical sympathetic is followed by dilatation of the blood vessels of the head, heightened temperature of the skin, increased secretion from the glands of the eye, and generally augmented sensitiveness of the parts so affected. The state of temporary relaxation of the vessels thus produced was attributed to *paralysis* of the vaso-motor nerves derived from the cervical sympathetic, which no longer ensured the normal contraction of the arterial walls, to accomplish which was held to be their normal function.*

The supplementary part of the experiment, relating to the effects of faradization applied to the central cut ends of the nerve, we shall consider separately.

Now, the question is, does section of the superior cervical ganglion cause paralysis of function of the ganglia of the brain proper, which, as we have seen, are semi-independent centres of nerve power, equally with the cervical ganglion itself. If the answer be in the affirmative, then it must be shown by those who so answer it, that the cranial ganglia are dependent for their vaso-motor power on the ganglia of the neck ; a conclusion which the facts just recited do not seem to warrant, and which appears quite gratuitous.

Besides, it is a well-known fact that the vaso-motor fibres of the sympathetic have their origin in the cranio-spinal axis ; and that the several ganglia throughout the whole length of the sympathetic chain are constantly re-inforced by motor and sensitive filaments derived from corresponding portions of the spinal axis.†

The cranial ganglia receive their motor supply from contiguous nerves of the spinal, or tubular form, within the cranium. Thus the ophthalmic, or ciliary ganglion receives a motor branch from the third pair. Meckel's ganglion is supplied by motor nerve influence from the facial nerve. The otic ganglion receives a motor branch from the same nerve, while the sub-maxillary ganglion receives its motor nerve from the chorda tympani, a branch of the facial.‡

Thus we see that all the conditions necessary for independent functional activity are found in these cranial ganglia, which, as in the case of ganglia generally, of the sympathetic, "are so many little magazines of nerve-force ;"‖ and that there is good reason to believe that these are in no way impaired in their local functional activity by section of the cervical sympathetic and their consequent isolation from the other ganglia of the sympathetic in the thorax, and other parts of the body.

200. We submit, then, with all due deference to the authorities, that paralysis of the cranial ganglia is not the result of section of

* Dr. Brown-Sequard, Lectures on Cent. Nerv. Syst., p. 140, etc. † Dalton's Phys., p. 514. Dr. Brown-Sequard's Lectures, etc., pp. 144, 148. ‡ Dr. Dalton's Physiology, pp. 514, 515. ‖ Todd and Bowman's Path. Anat., p. 509.

the cervical ganglion: and that it is far more probable that the deep wound necessary for exposing the sympathetic in the neck, and the act of cutting it, cause an irritation both direct and reflex on these ganglia, and corresponding effects on the fibres they supply to the blood vessels, which cause the latter to dilate and produce the phenomena referred to.

201. This interpretation of the experiment in question is not unsupported, if indeed it has not been already suggested or asserted, as will appear by what is to follow. An article "of much more than ordinary interest and merit, on the vaso-motor nervous system," appeared in the British and Foreign Medico-Chirurgical Review, which was copied from the concurrent London Lancet into the Canada Lancet of May, 1877, page 273, in which the writer gives a summary sketch of the progress of this chapter in physiology, from Pourfour du Petit, in 1727, down to the present time. Having stated the various steps of discovery, which have led to what is at present known on this subject, the writer continues, "This clearly states the modern theory as most usually accepted, and as innumerable hypotheses concerning the nature of obscure and so-called functional diseases and the action of remedies have been built upon it, *it is important to point out that this is quite inadequate to explain some other phenomena which have been observed, and that therefore it can only be considered as a partial expression of the truth.* Bernard, whilst investigating the secreting function of the sub-maxillary glands, found that irritation of the distal end of a cut chorda tympani nerve always dilated the blood-vessels of the tongue, and increased the secretion of the saliva, and Eckhard *demonstrated the presence of vaso-dilator nerves*, starting from the sacral plexus of a dog and going to the penis, to which he gave the name of nervi erigentes, as stimulation of them produced turgescence and erection of that organ. *Claims for other vaso-dilator nerves have also been put forward, and we must at any rate allow that* DILATATION OF BLOOD-VESSELS IS NOT NECESSARILY A PARALYTIC PHENOMENA OF THE VASO-MOTOR SYSTEM. Must we then admit that there is a vaso-dilator system as widely distributed as the vaso-motor or constricti ve system? *Goltz would explain all dilatation of blood-vessels as due to irritation of vaso-dilator fibres at the time of section*, and appeals to the temporary nature of the dilatation as a proof of this, for the arterial tonus is always speedily re-established. In addition, he teaches that the calibre of the blood-vessels is regulated by local centres, which are in subordinate connection with the sympathetic and cerebro-spinal centres. The experiments on which he bases his inferences have recently been verified . . . . . Goltz has also demonstrated that certain centrifugal *vaso-dilator* fibres have an independent origin from a centre in the lower part of the spinal cord, and other evidence supports the view that there are a series of

similar centres at intervals along the whole spinal cord . . . . We are, therefore, driven to a much more complex hypothesis than that which is generally adopted. Local vaso-motor centres are probably distributed universally in juxtaposition with the blood-vessels, and each receives not only a peripheral set of nerve-fibres, which must contain both vaso-constrictor and vaso-inhibitory or dilator fibres, but also a central or commissural set from a nerve centre higher in the scale. This is again connected with a centre higher up, and so on throughout the entire nervous system . . . It is obvious that if such an elaborate hypothesis be necessary, merely to hold together the well-ascertained results of modern experimental research, in this direction, and that even this may not do for long, more caution than is usually displayed must be taken before we invoke its aid in the explanation of our daily clinical and pathological observations, and in describing the modus operandi of our therapeutic agents."

202. From this article, and the very complicated schema of vaso-motor innervation quoted a few pages back, both of which are intended to convey the same modern theory, the following conclusions may be drawn :—

(a.) That the present vaso-motor theory is only a partial truth.

(b.) That it entirely ignores the inherent contractile power of the middle muscular coat of the arteries.

(c.) That it is inadequate to explain certain physiological phenomena.

(d.) That it lacks the simplicity and directness with which, in natural processes, means are adapted to an end.

(e.) That it requires an elaborate and complicated nervous apparatus, in which one set of nerves are directly pitted, functionally against other nerves of similar origin.

(f.) That this system is too complex and too unsatisfactory to be of practical use for clinical or therapeutical purposes.

(g.) That the assumed existence of inhibitory nerves is due solely to the exigency of the theory; for, as a matter of fact, they are not known to exist anatomically, while the existence, as well as the function of vaso-motor nerves, regulating the calibre of the vessels, have been demonstrated.

(h.) That dilatation of the blood-vessels is not necessarily a paralytic phenomena of the vaso-motor system.

(i.) That there are strong physiological grounds for believing in the existence of vaso-motor nerves, whose function it is to *dilate* the arteries, and that this evidence is furnished by advanced physiologists themselves.

In view of these facts, we are much encouraged in our endeavour to show that this elaborate hypothesis may be reduced to very simple proportions, and that but one set of nerves, to dilate the

arteries, is all that is really required ; the contraction of these tubes being amply provided for in the inherent contractility of their muscular walls.

We therefore proceed to produce further proofs that the interpretation here put upon the mode in which section of the cervical sympathetic affects the blood vessels of the head, is justifiable ; that is, that irritation and not paralysis of the vaso-motor nerves is the result of the section in question.

203. The partial closing of the eyelids, and the extension of the nictitating membrane across the eye, in the cat, witnessed in the celebrated experiment referred to, are regarded by Dr. Dalton, not as evidences of paralysis from division of the fibres of the sympathetic in the neck, but rather as occasioned by exaggerated sensibility [that is irritation] of the retina, as exists also in the integument : and the partial closing of the eyelids and pupil, he regards as a secondary consequence of that condition.*

204. Indeed, leading physiologists themselves, adopt the very mode of interpretation of similar facts for which we here contend, and in other experiments on nervous tissue, see in the effects of the irritation produced by section, the phenomena of excitation and not of paralysis. Thus, Messrs. Todd and Bowman, in referring to two experiments of Dr. M. Hall, which imply that the action of the sphincter is in part dependent on the cord, state :—" In both, [experiments], however, one on a horse, the other on a turtle, the observations were made immediately after the division of the cord. *By the division the whole organ was thrown into an excited state, both above and below the section,* and therefore manifested phenomena similar to those excited by volition. Indeed, *we have seen the sphincter repeatedly contracting, after the division of the cord,* without the application of any new stimulus to it ; and the dog continuing to raise and depress his tail, *as long as the irritation of the cord produced by the section has continued.*"†

Again, " In a state of irritation of the cord, such as may be caused by *traumatic injury*, erection, or semi-erection [of the penis], is frequently present."‡ To show that the same interpretation of the phenomena attending the section of nervous tissue is applied to the inter-cranial ganglia, as well as to the spinal cord, we quote the following :—" Destruction of the medulla oblongata is followed by the immediate cessation of the phenomena of respiration ; and this takes place whether it be simply divided or completely removed. When an animal is pithed [destruction of the spinal cord], he falls down apparently senseless, and exhibiting only such convulsive movements *as may be due to the irritation of the medulla by the section,* or such reflex actions as may be excited by the application of a stimulus to some parts of the trunk."‖ We would rather see

* Physiology, p. 523. † Physiol. Anat., p. 300. ‡ Ibid, p. 302. ‖ Ibid, p. 304.

the word "paralysis" in place of the word "irritation," in the line we have italicised; but if this mode of reasoning, or rather this interpretation of the effects of section of nerve tissue be applicable to the cord and medulla, it cannot be objected to by those who use it, or endorse it, in the case of the cervical sympathetic, consequently it justifies our theory and accounts for the excitation of the vaso-motor nerves of that ganglion, and the reflex excitation of contiguous ones in the cranial mass, dilating the vessels of the head, so long as the irritation produced by the section continues: and this, too, on what are regarded as sound physiological principles.

In other experiments on the olivary column of the medulla oblongata, Dr. Brown-Sequard regards the thrust of a needle or a section with a knife as equivalent to excitation, and not paralysis, of these centres:* so that the view here suggested as to the effect of section of the cervical sympathetic, finds support from other authorities also.

205. It may be said our argument is inconsistent in that we have just attempted to prove the cranial sympathetic ganglia independent of those in the neck, and that now we attribute dilatation of the cranial blood vessels to excitation of the cranial ganglia as a consequence of primary irritation, by section of the cervical sympathetic. It may be said, if these several ganglia are independent centres of nerve-power, irritation of one ought not to affect the others any more than paralysis of one would depress the others. But there is this difference. Irritation of a tissue, or of a nerve-trunk, is transmitted through the sensitive nerves to distant parts, and is known to influence even distant nerve centres: whereas paralysis is a negative condition, and can only affect the parts directly supplied by the paralyzed nerve itself. From this it will be seen that our argument is consistent throughout.

206. We come now to the supplementary part of this interesting experiment on the sympathetic of the neck. Dr. Brown-Sequard, and almost immediately after, Prof. Bernard and Dr. Waller, pointed out, that if a faradic current be applied to the cranial end of the cut cervical sympathetic, the phenomena of dilatation of the blood vessels of the head are reversed. A state of normal contractility ensues, the temperature declines, and the eye and its appendages return to their usual state.† Believing electricity to be an "excitant" to nervous tissue, these physiologists interpreted the phenomena in question in accordance with that theory, and saw in the assumed "stimulation" by electricity, of the cranial end of the cut nerve, a revival of its functional activity and a return of its ordinary control over the dilated vessels. Hence the conclusion that the normal function of the vaso-motor nerves is to *contract* the blood vessels.

*Lectures on Phys. and Path. Cent. Nerv. Syst. p. 194. †Dr. Brown-Sequard's Lectures, &c., p. 140.

207. We have had proof, however, that an electric current paralyzes the nerves; that its anæsthetic power subdues their irritability; soothes pain, and deprives them of their customary restraint over muscular fibre. Accordingly, we suggest that the true interpretation of the results of this part of the experiment is this:—That as a consequence of the paralyzing action of electricity on the previously irritated nerves, their dilating power is abolished, and the muscular fibre of the middle coat of the blood vessels is enabled to contract, as a result of its own inherent contractile power, when no longer restrained, and the calibre of the vessels is diminished accordingly, with a return to ordinary circulatory activity.

According to this view, *the contraction of the arteries is effected through the inherent contractile power of their muscular walls*, and this tendency to contraction is perpetually antagonized, during life, by the functional activity of the vaso-motor nerves, *the preponderance* of which, aided by the pressure of the blood, *results in a state of vascular dilatation.*

208. If the reader finds it difficult to accept this view of vaso-motor nerve action, and insists on adhering to the more orthodox opinion, that dilatation of the arterial tubes is the effect of paralysis of the vaso-motor nerves; and that when these nerves are excited, the calibre of the vessels is correspondingly reduced; we ask him to explain the general contraction of the arterial system which takes place within a few hours after death,* emptying the arteries into the veins, which are larger than the former,† leaving these collapsed and occluded.

The muscular coats of the lymphatic vessels in the tail of the tadpole empty themselves by contraction after death in the same manner,‡ and though in the case of both these and the arteries a subsequent relaxation occurs, this latter change is doubtless coincident with the loss of muscular contractile power owing to molecular changes from incipient decomposition.

209. Now if *paralysis* of the vaso-motor nerves be attended by *relaxation* of the arteries, as is the orthodox theory, then after death, when nerve-force is no longer operative, *the arteries ought to be dilated.* But such is not the case. Extinction of nerve force and arterial contraction go together, and so also does the effect of faradization. On the contrary, those stimulants, foods or medicines, which re-inforce nerve power, are found to dilate the arteries; so that when we suggest, (in opposition to the prevailing theory) that *arteries contract from the innate power of their muscular walls, and dilate in obedience to nervous stimulus*, we do so on true physiological principles and in strict accordance with physiological facts.

210. The remarkable effects of irritation of the fifth pair of cranial nerves in exciting destructive inflammation of the eye, are well-

* Dr. Carpenter's Phys., p. 334. †Dr. Burdon-Sanderson, Hand-book Phys. Lab., p. 239. ‡Ibid, p. 454.

known, and are frequently seen in the loss of one eye from irritative changes taking place in the other.

Experiments have shewn that if the ophthalmic branch of this nerve be divided in front of the casserian ganglion, inflammation of the eyeball follows, with much certainty. But when a division of the nerve is made behind that ganglion, no inflammation follows. This difference in result has been attributed to the section of certain fibres of the sympathetic, which join the ophthalmic nerve in front of the ganglion, but are absent in its rear.* Here again, the phenomena are interpreted as due to paralysis of the sympathetic, which permits dilatation to occur when its contracting power is suspended.

Does not the experiment as reasonably establish that the nearer the ophthalmic ganglion is approached by a painful operation, the greater is the risk of irritating it, and thereby of producing a temporary exaltation of its dilating power, as we see in the inflammatory effects witnessed? This view of the case is strengthened by the well known effects of ganglia in retarding impressions which pass through them,† so that in section behind the ganglion, this fact, as well as the greater distance from the eye, must be taken into account in estimating the results: and so also should the dreadful injury inflicted on the nervous system by the removal of portions of the skull and brain, in order to reach and divide these deeply seated portions of nervous tissue, as is the mode sometimes practiced.‡

That the inflammatory effects on the eye referred to, are due to irritation, rather than paralysis, of the vaso-motor filaments contained in the fifth pair, after its section, finds support in the effects of the operation on the animal experimented on. Dr. Carpenter describes these as follows:—"When the whole trunk is divided within the cranium, by the penetration of a sharp instrument, (which Magendie, by frequent practice has been able to accomplish) evident signs of acute pain are given. After the incision has been made through the skin, the animal remains quiet until the nerve is touched; and when it is pressed or divided, doleful cries are uttered which continue for some time, shewing the *painful effect of the irritated state of the cut extremity.*"‖

211. *Experiment on the sub-maxillary gland.*—This gland receives its nervous supply from the chorda tympani; a branch of the facial nerve, which in turn is an intra-cranial spinal motor nerve. As the chorda passes to the gland, it is involved with, and is undistinguishable from, the fibres of the sub-maxillary ganglion. A third nervous supply is that from the superior cervical ganglion of the sympathetic, namely, vaso-motor or vascular nerves, which accompany the branches of the carotid artery to the gland.

The peculiarity of the experiment is, that if the chorda tympani nerve be faradized, the local arteries dilate and an afflux of blood

* Dr. Dalton's Physiology, p. 523. † Dr. Carpenter's Physiology, p. 830.
‡ Dr. Ott, Action of Medicines, p. 62, &c. ‖ Human Physiology, p. 683.

to the gland, with increased secretion, is the result; whereas if the sympathetic be similarly treated, the arteries of the gland contract, blood supply is diminished and secretion arrested.*

212. These results appear to favor the popular vaso-motor theory, and are often referred to as a proof of its validity; and correctly so, if electricity be an "excitor" of nervous tissue. The contraction of the arteries of the gland, under faradization of their vaso-motor nerves, is pointed to as a proof, both, that electricity is a "stimulus," and that it is the proper function of the vaso-motor nerves to restrain the calibre of the vessels; since this is the result of their "excitation."

But the considerations suggested in a previous part of these pages, shew that this mode of interpreting the phenomena in question is not in accord with other general physiological facts; and especially with the one just shewn, that vascular contraction is found most generally and vigorously, not when the vascular nerves are excited, but when they are dead. There must, then, be some other mode of explaining the results of this experiment on the gland in question; and we have again to suggest that the application of our theory to the results reported, is at once simple and natural.

In former pages, the effect of faradization in paralyzing motor nerves, and as a consequence, producing a rapid series of contractions and relaxations of the muscular fibres to which these nerves are distributed, has been fully set forth. (§ 148). By faradizing the chorda tympani,—a motor nerve—the tissues of the gland and adjoining parts are subjected to this mode of influence and are mechanically excited. Blood and pabulum are thus attracted to the area of these vibratory changes, with a consequent increase of functional activity, as seen in the augmented secretion. Dr. Brown-Sequard says of this part of the experiment, "I think that this enlargement of the blood vessels must be due to a greater attraction of the arterial blood by the tissue of the gland; and we explain this increased attraction by the production of the chemical interchanges between the secretory tissue and the blood, which are rendered manifest by the secretion of saliva then taking place."†

Ludwig's explanation is to the same effect; and though not so intended, accords well with the effects here attributed to faradization. Thus, to quote Dr. L. Brunton, "It was first demonstrated by Ludwig that the increased secretion produced by excitation of the chorda is immediately dependent on increased activity of the function of the secreting elements of the gland, and *not on changes in the blood vessels;* in other words, that in the sub-maxillary gland the process of secretion is not a mere filtration, but is effected by changes which go on within the gland itself, of such a nature as to determine a current from the circulating blood towards the duct.

*Dr. L. Brunton, Handbook Phys. Labor., p. 468. Dr. Brown-Sequard's Lectures on Phys. and Path. Cent. Nerv. Syst., p. 149. †Lectures, etc., p. 149.

This conclusion was based by Ludwig on the observation: first, that if the duct is constricted, secretion continues, notwithstanding that the pressure in the interior of the gland is greater than that in the arteries; and secondly, that secretion continues after circulation has ceased, *e. g.*, after the head has been severed from the body.*

So much for the effects produced through the chorda tympani; and now as to the effects shewn to result through the vaso-motor nerves of the sympathetic. Here the same paralyzing effects of faradization withdraws the control of these nerves from the arterioles with which they are associated; contraction of the muscular fibres of these tubes results, reducing their calibre, diminishing the supply of blood to the gland, and as a consequence, arresting its secretion. On this view, physiological consistency is maintained, for nervous torpor, whether from the death of the body, from temporary paralysis by faradization, or, as we shall see by and by, from the paralyzing effects of certain drugs, is invariably associated with a contracted condition of the arterioles, lessened circulatory activity and diminished secretion.

213. A supplementary experiment on this gland consists in cutting both the chorda tympani and the sympathetic, when increased secretion results, *not however for some time after section*, and may last for days or weeks.† May not the interval which elapses before the commencement of increased functional activity correspond to the time required to set up irritative action in the cut nerves and their vicinity; and the irritation thus transmitted to the tissues of the gland, by the chorda, and the dilatation of the arterioles, by similar irritations transmitted along the vascular nerves, account for the increased secretion, which subsides after the irritative condition has ceased by the re-union of the nerves and the healing of the wound? It is true that sthenic inflammatory action, at first, arrests secretion; but the action resulting here, on the gland, is only secondary, and is not sthenic. We know also that increased secretion is the rule, in the lower grades of inflammatory action, and in the second stage of even the active forms, so that there is nothing in the explanation here offered against which exception can reasonably be taken on this ground.

214. Another observation which has been made, is, that the presence of curare in the blood affects the gland in a similar manner as section of the nerves; and as curare is known to poison the terminal fibres of the motor nerves, the condition, at first sight, seems unfavourable for a dilatation of arteries and increased secretion, on the theory here suggested. Dr. Michael Foster, however, after detailing the effects of curare, or urari, poisoning, states, that the facts are intelligible only on the hypothesis that while the motor nerves are paralyzed, *the sensory and central nervous system*

*Handbook for the Physiol. Laborat., p. 468. †Dr. Brunton, Handbook Physiol. Laborat., p. 473.

escape, if the poisoning be not too profound; in which case this influence on the gland, it is implied, will not appear for, "in order to bring these results out well, the dose of poison must not be more than sufficient to poison the motor nerves."* In these unparalyzed sensory nerves and nervous centres, acting through the vascular nerves, which may be presumed to escape a moderate dose also, since the sympathetic system is less easily impressed than the cerebro-spinal, we have sufficient nerve life to account for the continuous secreting activity, even amid surrounding motor paralysis.

We have, in these references, courted the severest tests to which the theory here suggested can be subjected, in the very latest published details of physological research; and if the suggested explanations we have had to offer are in some respects hypothetical, it ought to be remembered that they are pitted against mere hypotheses on the other side; and as we think the candid reader will concede, with very much both in physiology and fair induction, to support them.

215. The effect on the tissues, to which the chorda-tympani is distributed, as we have just seen, is conveyed directly through a motor-nerve. But similar effects occur through impressions made on sensitive or afferent nerves, conveyed by them to the nervous centres, and from thence reflected either through motor-nerves, in the tissues, or through the vascular nerves on the blood vessels, contracting or dilating the same as the impression is of an exciting or depressing character.†

Dr. Brown-Sequard has given a ready illustration of this reflex power of sensitive nerves over the blood vessels. He has shown, that if one hand be placed in a basin of cold water, the blood vessels of the other hand contract the more and the sooner, in proportion to the intensity of the impression of cold.‡

Is the impression on the sensitive nerves, in this case, of an exciting or depressing kind? Does the impulse which is transmitted from them through the nervous centres reach the vaso-motor nerves of the blood vessels as a stimulating or paralyzing influence?

On the generally accepted theory of vaso-motor innervation, the impulse in this case must be an exciting one, because, according to that theory, *excitation* of the vaso-motor nerves induces arterial *contraction*. But, surely the benumbing and paralyzing influence of cold is too well known, in these latitudes, to admit of its being considered a stimulant to nervous function.

216. Dr. Sidney Ringer, in referring to the influence of cold and the effects of Dr. Chapman's spinal ice-bags, attributes the results to the *paralyzing* effects produced on the nervous centres. But in accordance with the prevailing theory, he holds that paralyzing the vaso-motor nerves permits relaxation of the arterioles, thereby

* Handbook Phys. Labor., p. 400. †Dr. Beale, Disease Germs, p. 331. ‡Lectures, etc., p. 146.

favoring dilatation. He quotes Dr. Chapman's practice of applying ice to the cervical spinal region when more blood is needed for the head ; and to the lower part of the spine when it is desired to direct increased blood to the abdomen, pelvis, &c.*

We have quoted Dr. Ringer here simply to utilize his authority in proving that the effects of cold, in Dr. Brown-Sequard's experiment, is what we claim it to be—a paralyzing one. The fact that the arteries of "the other hand" were contracted by the paralyzing effect on the sensitive nerves of the hand dipped in cold water, though tallying well with our theory, is at direct variance with Dr. Ringer's —which is also the popular theory ; for paralysis of the vaso-motor nerves, ought, on this view, to have produced dilatation rather than contraction of the arteries, on which this influence was exerted.

Hence, either the theory intended to illustrate Dr. Chapman's practice, or the result reported, must be erroneous ; for arterial contraction and nervous paralysis, or death, go together ; as do also arterial dilatation and nervous activity.

If Dr. Chapman's reported results be correct, would not a much simpler and truer explanation be, that the blood driven out of the superficial spinal vessels by the influence of cold in contracting them, and obliterating their calibre,† seeks a refuge elsewhere, in vessels not subjected to the same influence, in the portion of the body corresponding to that portion of the spine acted on, e. g., in one case, in the brain, and in the other, in the viscera of the abdomen ?

217. *The effect of "pithing" or section of the medulla oblongata on the arterial system :*—We have yet to notice another physiological experiment, which without due consideration is sure to be quoted to our disadvantage. It is the statement that when an animal is pithed. or " if the medulla is divided immediately below the cerebellum, *all the arteries are relaxed.*"‡ It will doubtless be said that if our theory were true, when the influence of the vascular nerves, which we claim to be dilators of the arteries, is withdrawn, by destruction of the cerebral or spinal centres, general arterial contraction, and not relaxation, should follow. Not only so, but the result stated, will be pointed to as a proof that the nerves are directly concerned in maintaining arterial tonus, or contractility, as shown by the alleged relaxation which attends their destruction.

We have already, in previous pages, discussed the cause of muscular relaxation, and the same considerations which apply to relaxation of muscles generally, may be held to apply to the muscular fibres of the arterial walls. But we are quite content to let the considerations in question pass, and to consider this experiment and the inference drawn from it solely on its own merits. In order to place the facts fully before the reader, we quote from Dr.

* Therapeutics, p. 34. † Dr. Carpenter's Physiology, p. 485. ‡ Handbook for the Physiol. Lab., p. p. 244-45.

Burdon-Sanderson,* the entire paragraphs relating to it, as follows :—

"Two frogs are slightly curarized, and placed side by side on the same board in the supine position. In both the heart and great vessels are exposed, as in the preceding section. It having been ascertained that the circulation is normal in each animal, and the frequency of the contractions having been noted, the brain and spinal cord are destroyed in one of the frogs, by inserting a strong needle into the spinal canal, immediately below the occipital bone, and then passing it upwards and downwards. This may usually be accomplished without much loss of blood. If now the frog which has been deprived of its nervous centres is compared with the other, it is seen that in the former, although the heart is beating with perfect regularity and unaltered frequency, it is empty, and in consequence, instead of projecting from the opening into the anterior wall of the chest, it is withdrawn upwards and backwards towards the œsophagus."

"The emptiness of the heart is not limited to the ventricle and bulb. The auricles are alike deprived of blood ; and if the heart is drawn forwards by the apex, it is seen that the sinus venosus and vena cava inferior are in the same condition. The state of the heart is therefore not depending on any cause inherent in itself, but on the fact that no blood is conveyed to it by the veins. To make this still more evident, the rest of the visceral cavity may be opened, when it is seen, that although the vena cava is collapsed, *the intestinal veins are distended.* The second frog, which is no longer required for comparison, should now be pithed in the same manner as the first. A canula is then introduced into the abdominal vein, with its orifice towards the heart, and connected by an india-rubber tube guarded by a clip, with a funnel containing three-fourths per cent. solution of chloride of sodium. The heart having been exposed and its empty condition noticed, the clip is opened. Its cavities at once distend, and it acts as vigorously as before the destruction of the nervous centres."

"The experiment may be varied thus: Two frogs are suspended side by side, one of which has been pithed in the manner above described. In both, the heart is exposed and the ventricle cut across. In the pithed frog, *a small quantity of blood escapes;* the quantity contained in the heart itself and the commencement of the arterial system. In the other, *blood continues to flow for some minutes* in consequence of the continued contraction of the arterial system. To what extent the veins may participate in it is uncertain."

"These simple experiments shew, first, that in the frog, the arteries unaided by the heart, continue the circulation for a certain time after equilibrium of pressure has been established, by virtue of

* Handbook for the Physiol. Labor., p.p. 245-6.

their contractility; and secondly, that in this animal the influence of arterial contractility in aid of the circulation is so considerable that, when it is abolished, circulation is no longer possible."

"It may be well to point out that this fact affords no ground for supposing that the arteries take any active part in maintaining the circulation. All that is proved is, that in the relaxed state, the vascular system of the frog is relatively so capacious that it is more than large enough to contain the whole mass of the blood, which consequently comes to rest in it *out of reach of the influence of the heart.*"

218. It cannot be said, that in this lengthy quotation we have not done full justice to the author and the facts as he recounts them. We desire to make the following comments :—

1. The heart is empty, and so are also the great vessels leading to and from it. The cavities of the heart are closed, although its rhythmical contractions continue, as is shown by the manner in which "its cavities at once distend," when the saline solution is directed towards them from the funnel.

2. Not a word is said about the condition of the systemic arteries, although it is the object of the experiment to prove that these are relaxed: For it is to the arteries, and not to the veins, that vaso-motor control is directed; and it is in the condition of the arteries that the all-absorbing interest of the experiment lies. This omission is very significant.

3. This author informs us elsewhere,* that the veins are about one-sixth larger in diameter than the arteries. Consequently the venous capacity is larger than the arterial. In the experiment, the veins are found engorged with blood: and it would really appear that the contracted heart, aided by the contractility of the arteries, had *emptied this system of blood and driven it into the veins,* which are mechanically dilated in consequence. The venous blood, however, is unable to pass the portal capillary system, and hence, through both these influences, the blood is kept in the large and lax venous system "out of reach of the influence of the heart."

4. The variation in the experiment shews that of the two frogs, the arterial system of the *pithed* one, which ought to be relaxed, *really contains least blood.* "Only a small quantity of blood escapes, the quantity contained in the heart itself, and in the commencement of the arterial system," which is the most rigid and least contractile portion of the arterial tubes, and consequently retains a little blood.

In the *unpithed* frog, "the blood continues to flow for some minutes," the full arterial vessels relieving themselves through the nearest and easiest outlet, that of the cut in the ventricle. This is just what was to be expected from the arteries, "by virtue of their contractility." But had the arteries of the pithed frog been "re-

* Page 239.

laxed," as we were promised they would be, more blood should have flowed from the ventricular wound of this frog than from that of the unpithed one; because the distended arteries would have poured out their contents so freely that the phrase "only a small quantity," would have been quite inapplicable.

5. Is it not the fact, that the arteries of the pithed frog, as well as the heart, had previously contracted to the utmost, forcing the blood into the veins, in the manner referred to above, and that this result accounts for the small flow of blood from the frog in question?

6. We think that the student of physiology has a right to complain of the use which is made of this experiment, and of the inference sought to be drawn from it by the distinguished author of this part of the Handbook. It appears obvious, that so far from sustaining that inference, it accords with facts otherwise observed and recorded, namely, that in death, when nerve-force is extinct, the inherent contractile power of the arterial walls, and the similar walls of ducts and absorbents, invariably contract and empty these tubes by the nearest outlet; that is, by pouring their contents into the veins.

The candid reader, we are sure, will agree with us, that the experiment, at first sight so apparently fatal to our theory, is really and unexpectedly a proof of the soundness of the view we advocate.

219. Let us apply this theory to other conditions of the body where vaso-motor innervation is involved. Take a person, of either sex, who from anæmia, sedentary habits, or general *malaise*, has a languid circulation, with habitual coldness of the extremities. Thousands of such are to be found in real life. On the accepted theory, the contracted state of the blood vessels of the extremities, on which this coldness depends, is due to *excitation* of the vaso-motor nerves, since, on the same theory, it is the function of these nerves to reduce the calibre of the blood vessels, and the more that function is exalted, that is, the higher the degree of nerve excitation, the more intense and prolonged will be the capillary occlusion, with the corresponding effects of chill, paleness, etc., going on, to suspension of the circulation, as we see in the rigors of ague, the collapse of cholera, etc.

In the class of cases supposed, is it reasonable to assume that any part of the vital functions are over-active? What would be thought of a physician who, consistently carrying out the popular theory, directed his treatment to lowering the—supposed—exalted activity of nerve-force? As a matter of fact, do not our prescriptions in such a case tend to augment vascular activity, and, as a step to this, to favor vascular dilatation? But, on the same theory, arterial dilatation is the result of vaso-motor *paralysis*.*

In endeavoring to improve the tone and vigor of the circulatory activity, then, are we really paralyzing these nerves? Fortunately

* See previous references.

for the patient, as well as for medical science, the theory which *ought* to govern us here, is practically ignored. Indeed, it is untenable. For who can believe, that in the state of general arterial contraction witnessed in cholera, when the smaller vessels are so occluded as to render the surface of the body blue and livid, when even the breath is cold, and the victim of the disease pulseless, that this state is the result of an over excitation of the vaso-motor nerves; or that any part of the nervous system is excited amid such general depression! Why, even the very spasms or "cramps" which accompany the disease, bear witness to the withdrawal, rather than to the activity, of the nerve-forces. (§ 94.)

220. How much more natural and consistent it is, in view of all the circumstances, to regard vaso-motor and all other nerve-force as greatly reduced in these cases, and unable to overcome the inherent contractile power of the muscular tissue of the vascular walls; that, as a consequence, the latter fulfils the law of its existence, and finding itself no longer sufficiently restrained, contracts these vessels accordingly: that, in extreme cases, as in cholera and poisoning by aconite, a contraction and occlusion of the smaller vessels sets in during life, as occurs the moment death puts an end to nervous control over muscular contractility; for in death the arterial tubes are found empty and their calibre obliterated.*

This view of the case is strengthened by the remedial measures which antidote these cases of extreme vascular contractility. Warmth, friction, moderate stimulants, etc., are precisely the means which help to restore the balance of nerve-power, and through it to expand the contracted vessels and restore circulatory activity: whereas these very remedial effects would prove fatal if the state in question depended on an exalted nervous activity, and this already abnormally heightened nerve-power were to be still further increased.

221. Again, why are certain persons unable to sleep after severe or protracted mental effort? Here, increased blood has been directed or attracted to the brain, along the dilated vessels. Nervous activity is at its height, and yet vaso-motor nervous activity fails to induce vascular contraction and that state of comparative anæmia of the brain on which sleep depends.

On the popular physiological theory, arterial contraction is the result of excitation of the vaso-motor nerves. Then the blood vessels should now be contracted, for the whole cranial mass is throbbing with excitement. To meet this difficulty, physiologists assume that after a period of excitement, the vaso-motor nerves become paralyzed, and while in this state are unable to exercise their normal control over the calibre of the vessels, which, as a consequence, remain dilated.

* Dr. Carpenter's Physiology, pp. 485, 334.

222. We have before referred to the frequency with which "paralysis of the sympathetic" is made to do duty in circumstances of ordinary occurrence, as flushing of the face, and blushing; events of quite a trifling character compared with the serious nervous lesion implied in this phrase. It appears to have been the exigency of a theory rather than any shadow of foundation in fact, which first caused this assumption to be promulgated; and it continues to hold its place, partly from the same necessity, and partly, no doubt, in deference to the great names with whom it originated.

Until the "paralysis" theory is supported by evidence, is it not far more reasonable to assume, as we know the cranial nerves are excited, that the vaso-motor nerves share in that excitement; and as a consequence of their temporarily increased dilating power, that they are able to over-balance the purely physical contractility of the muscular fibres of the vascular walls, which remain unduly dilated until time and cessation of the mental efforts have enabled this nervous excitement to subside; when the contractile force embodied in the vascular tubes suffices again to restore them to their customary calibre, and with this, the equilibrium of the circulation.

223. There are other cases where wakefulness may be caused by excessive anæmia of the brain, in exhausted states of that organ. Here the vascular fibres are predominant, and the blood vessels are immoderately contracted, not from vaso-motor excitation, but from the opposite state. What is needed in this case is a moderate stimulant, or nutritious food, to improve the tone of the weakened nerves. It is in both these conditions, of hyperæmia and anæmia of the brain, that a "night-cap" in the shape of a glass of sherry or whiskey, is, with many persons, conducive to sleep. The dose will require to be measured according to the previous habits and experience of the individual. In the state of anæmia, the nerves are to be reinforced, and a moderate potion, or a little easily digested food, may suffice. In the wakefulness from mental excitement, a larger dose will be necessary, because here the stage of stimulation must be slightly passed, and the arena of narcosis entered upon. Then the excited vaso-motor nerves receive their *quietus* in a moderate degree of paralysis. The contractile muscular fibres of the vessels, being independent of ordinary vital influences, are thus enabled to exert their normal control, and the vessels pass into the state of contraction favorable for sleep. It is not to be inferred that we are recommending this mode of procuring sleep to our readers. We are simply utilizing our theory for the explanation of certain phenomena, with which many of them are doubtless more or less practically familiar.

224. We desire now to refer, briefly, to the phenomena of erection, in connection with this vaso-motor theory. In doing so, it is neces-

sary to invite attention to the peculiar structure in which erection, at least of the penis, occurs, even although the full mechanism of the process is apparently but imperfectly understood. It has been demonstrated that "in the penis there are two sets of arteries, one destined for the nutrition of the tissues, and communicating with the veins in the usual way, through a capillary network; while the other set, consisting of short tendril-like branches, form arterial diverticula, which, although they project into the venous cavities, do not appear to possess any distinct apertures communicating with them.

The erectile tissue appears essentially to consist of veins, with varicose enlargements, enclosed in a fibrous envelope, with trabecular partitions. Prof. Kolliker finds that this enveloping tissue contains a large amount of non-striated muscular fibre, and he maintains that it is the office of this muscular fibre, in the quiescent state of the organ, *i. e.*, in the intervals of erection, by its tonic contraction to compress the venous network, and so to shut out blood, which by its *vis a tergo* might otherwise keep the veins distended. This distinguished observer also maintains that when erection is about to occur, nervous influence is exerted to *relax* this enveloping muscular tissue, whereby free distension of the cavernous veins and of the arterial diverticulæ is permitted.*

How well this accords with the theory here advocated! We have increased vaso-motor nerve-force dilating the ordinary and extraordinary arterial tubes, and increased *motor* nerve-force dilating or *relaxing* the previously contracted muscular tissue, which surrounds the venous convolutions; and thus both systems of nerves conspiring to bring about the same result,—an influx of blood.

No one will deny that an excitation of the nerves is present in the state of erection. But if this be true, it presents a difficulty for the adherents of the current theory. For on that theory vaso-motor nervous excitation implies vascular contraction, which obviously is not present in the state in question.

*Dr. Carpenter's Human Physiol., pp. 501-2.

CHAPTER VII.

HOW THIS THEORY ACCORDS WITH THE PHENOMENA OF INFLAMMATION.

225. There is a general concurrence of opinion among physiologists, that in many cases of inflammation the first morbid change takes place in the tissues.* Dr. C. Handfield Jones regards this primary tissue change as not the starting point, in the majority of cases. He says:—"More commonly we meet with conditions where the neuro-vasal *paralysis* seems to be primary, and to depend on the direct action of a poison on the nerves and vessels."†

Here it is directly implied that the dilated condition of the blood vessels, in inflammation, is a result of paralysis of the vaso-motor nerves, whose function, as we have already seen, is presumed to be to contract the vascular channels. Similar expressions, embodying the same theory as that we have been heretofore combating, abound in recent medical literature, when treating of circulatory phenomena, and need not be more specially quoted. Our medical teachers everywhere assume that nerve-force is a stimulant, or compelling power to muscular fibre, and causes its contraction in the blood vessels as well as in the case of the muscles.

Now we have, in the preceding pages, evidence to show, that all the phenomena of muscular contraction, in its various forms and under diverse circumstances, can be accounted for independently of nerve-force; that nerve-force does not act the part of a stimulus or compelling power in bringing about muscular contraction anywhere: and that, in short, muscular fibre passes into a state of the most rigid contraction, as in rigor mortis, when nervous influence is wholly withdrawn. This being the case, can we belive that vaso-motor nerve-force is *exceptionally* exerted to secure contraction of the blood vessels, and that the muscular fibres involved in this act, do not follow the same law which governs muscular fibre elsewhere, especially when the muscular fibres of the blood vessels are known to possess, equally with similar fibres in other parts of the body, the power of self-contraction, when free to act, and are known to exert that power wholly independent of nervous influence, as in the contraction and obliteration of their calibre, after the death of the body?

226. In addition to what has already been said on the inherent contractility of muscular fibre, we would remind the surgeon of how

* Dr. Carpenter's Physiology, p. 566. Dr. Brown-Sequard's Lectures, &c., p. 174. Sir James Paget, &c. † Braith. Retros., July, 1876, p. 18.

frequently he is a witness of this property, not only in the retraction of the muscles, but in the obliteration of the calibre of the smaller blood vessels at the point of section.

We would also suggest that in the operation practised upon the cut ends of arteries, known as torsion for the arrest of bleeding, the hæmostasis is not the result solely of the twisting of a portion of the arterial tube, but is in part depending on the destruction and paralysis of the vaso-motor nervous filaments, which Dr. Beale has shewn to ramify upon and among the muscular tissue of these vessels. In consequence of this paralysis of the nerves which dilate these tubes, the contractile power with which the arteries are endowed is enabled to exert itself, and thus hæmorrhage is more effectually prevented than it would be by the simple twisting of the vessels. Thus it has been shown by Dr. Bryant, as a result of numerous experiments, both on dead and living subjects, that "in no single instance was there any evidence that the portion of vessel which had been twisted had lost, or was likely to lose, its vitality; or that the parts about the vessel had received any material injury."

And further, "In no case does it appear necessary, or even prudent, to twist the vessel till the end is twisted off; for by so doing we do away with the chief safeguard against bleeding."* Does not this evidently imply—though not so intended—that the twisting must be sufficient to paralyze the dilating nerves, but not enough to seriously damage the contracting muscular fibres?

227. We have already seen, in Dr. Brown-Sequard's experiment, (§ 215), that to the sensitive nerves belong the power of initiating impressions, which through the nervous centres are transmitted to the vaso-motor nerves, and as these impressions are exciting or depressing, the influence of these nerves in restraining the contractile power of the vascular channels is increased or lessened, and dilatation or contraction of the vessels results accordingly.†

What has been proved to be true of the circulatory activity of one part of the body must be true of other organs and tissues. If the sensitive nerves of the cranio-spinal axis be irritated by a burn, or a bullet, or those of the sympathetic system be similarly impressed by disease germs, have we not a right to conclude that the reflex or ultimate effect of these sources of irritation on the corresponding vaso-motor nerves will be of a similar character; and that not paralysis but heightened activity will be the result: the increased dilating power thus invoked overcoming the contractile tendency of the vascular walls, permitting expansion from blood pressure, thus producing congestion and inflammation accordingly. Vaso-motor *excitation*, then, and not *paralysis*, would appear to be the true condition existing in the congestive stage of the inflammatory process.

*Med. Chir. Trans., Vol. 61, 1868, p. 199. Braith. Retros., July, 1869, p. p. 116, 117. †Dr. L. Beale, Disease Germs, p. p. 330, 423.

228. That this is the true explanation, is further proved by the treatment adopted for the inflammatory process. Take an average sthenic case of ordinary occurrence. There are fever and the usual symptoms of acute congestion, with dilatation of the blood vessels, constituting hyperæmia of the tissue or organ affected, and perhaps also of contiguous organs.

Now, in this case, the determination of blood to the part inflamed, is a very important factor in the process ; and of itself has much to do with the termination of the disease, favorably or otherwise. This is proved by a number of recorded cases of inflamed and suppurating joints, or parts of limbs, where ligature of the principal arterial trunk of the limb has been followed by prompt and permanent amelioration of all the symptoms—previously severe—and an early cure of the inflammatory process.*

In the case just supposed, we cannot but believe that a diminution of the calibre of the engorged vessels, and a consequent lessening of the hyperæmia, would favor a slower growth of bioplasm (Dr. Beale) and tend to promote healthy cell-growth, and so favor recovery.† Let us, however, adopt the popular theory, and regard the vaso-motor nerves as paralyzed, and so unable to furnish the necessary "stimulus" or nerve force, to compel contraction of the dilated vessels. Do we, as a matter of fact, act upon this view of the case, and set about stimulating or "toning up" the paralyzed nerves, with a view thereby to restore arterial contraction ? Not at all !

What are the remedies we employ ? Aconite, veratrum viride, opium or its compounds, occasionaly tartar-emetic, and other remedies of a similar class, conjoined with warm poultices to the external surface. These will suffice for the ordinary typical case which we are discussing.

What are the effects of these remedies ? We call them "sedatives," and all sedatives are to a greater or less extent, paralyzers. (Dr. Anstie.) Examined carefully, every one of them will be found to lessen the activity of either sensitive or motor nerves, or both : and if pushed to their ultimate effects, their paralyzing effects on the nervous system will be abundantly apparent. Here again the theory we are taught is ignored, and fails to exert its influence on the recognized treatment.

229. Apply this treatment to the theory propounded in these pages. Regard the vaso-motor nerves as not paralyzed in the inflammatory state, but irritated and excited ; not as compelling, by a stimulus, the muscular fibre of the blood vessels to contract ; but as restraining it from contraction, in the normal state ; and now, that this restraining power is exaggerated, by the intensity of nerve action, producing abnormal dilatation of the blood vessels. These

* Braith. Retros., January, 1876, p. p. 125, 132. † See Dr. Wilks, Braith. Retros. July, 1869, p. 35.

several drugs, in one way or another, some acting on the sensitive nerves, allaying, or rather paralyzing, their functional activity; others acting similarly on the nervous centres, or on the vaso-motor nerves directly, lessen the undue nerve-power by a process of partial paralysis, and proportionably set the muscular fibres of the vascular coats free to fulfil their natural law of contractility; and, in doing so, to reduce the dilated vessels to their normal calibre, and so equalize the circulation, diminishing the hyperæmia and favoring a return to the healthy state.

Is not this explanation very simple and natural, and quite in accordance with what we daily witness?

We have not alluded, for want of space, to other remedies which may be called for in particular cases or stages of the inflammatory process. Those mentioned will suffice for the cure of the greater number of typical cases; and as for others, a careful examination of their effects will shew them to be either excitors or depressors of vaso-motor innervation, and to dilate or contract the vessels accordingly, producing corresponding results in the tissues and parts to which they are supplied; or to be remedies which impress the tissues directly, without the intervention of the nervous system.

We might dwell at further length on the phenomena of this state, and on the action of remedies in effecting its cure. We might also quote numerous cases in illustration of the truth of the views just expressed; but we are addressing intelligent physicians who have time and again witnessed the recovery of persons from inflammatory affections by the means indicated, and to them such details are unnecessary. Their own ordinary experience will recall confirmatory examples of this kind. And it is well known that under this natural and scientific mode of treatment the severity and danger of the inflammatory process has been greatly lessened, compared with the results of a former treatment, in which general depletion and antiphlogistic regimen of a lowering kind was often pushed to an extreme. We therefore leave these brief observations to the reader and pass on to other considerations.

ADAPTATION OF THIS THEORY TO THE FEBRILE STATE.

230. The theory here propounded is equally adapted to illustrate the phenomena of the febrile state.

The first effect of the development within the system of the the germs of fever, or of their intrusion from without, is a general depression of nervous energy, in which the vaso-motor nerves of the blood-vessels also share. As an immediate consequence, the restraining power of these nerves over the muscular walls of the arterioles is reduced, and if this lowering of power sinks below a

certain point, the muscular fibres of the vessels, no longer adequately restrained, exercise their contractile power, so as, to a greater or less degree, to obliterate the calibre of the blood-vessels and proportionately to prevent a due supply of blood from reaching the surface of the body and extremities. A degree of paleness, chilliness and diminished exhalation from the surface of the body results. A further reduction in vaso-motor power intensifies this effect, and joined with consecutive depression of the motor nerves restraining the muscles, gives to muscular fibre throughout the body such a preponderance that irregular contractions of the voluntary muscles may occur, constituting a "rigor" or "shake," so often experienced in the cold stage of ague.

231. This depression of motor force, however, is not permanent. The spasm of the smaller blood-vessels which has prevented circulatory activity in the extremities and external surfaces, has determined an unusual supply of blood to the internal organs and nervous centres. Perhaps partly from this cause, often, no doubt, aided by artificial warmth or restoratives, the nervous energy is regained, and may even soon be in excess of the force necessary to antagonize the muscular fibre of the vascular channels; and these, acted on by blood-presence, become unduly dilated, inducing an accession of the febrile state.

In some cases the subsequent history will show a repetition of these extremes, chilliness being mixed with fever, indicating that the contending nerve and muscular forces are carrying on their antagonism with varying results; sometimes one of these having the preponderance and sometimes the other; now muscular fibre gaining the mastery, and by lessening the calibre of the arterioles, producing a chill; then vaso-motor innervation triumphing, compelling the constricting fibres to relax and the vessels to become dilated.

Rarely is nerve-force long held in abeyance. Usually after the first onset, in the severer forms, it assumes control and maintains a dilated state of the vascular channels constituting the febrile state, which may be nearly continuous, but, except in the more intense forms, usually admits of partial remissions, with a proportionate return to a normal state of the circulation.

232. Nor is this preponderance of vaso-motor nerve-force in the presence of general languor and prostration at variance with the theory here propounded, as will appear from the following considerations.

During an attack of fever a much larger amount of nitrogenous elements of the tissues undergoes transformation into urea and other products for elimination than is to be accounted for by the quantity taken in as food. To supply this excess the fixed albumen of the tissues breaks down, and is transposed into these excreta. "In

all fevers the muscles become wasted, and on microscopic examination *the muscular fibres can be seen in the act of disintegration.*"* "Fatty degeneration of the tissues sets in during the progress of a fever, especially when prolonged. This degeneration has been observed more particularly and fully in the liver, kidneys, heart, blood-vessels and voluntary muscles."†

The contribution which muscular fibre throughout the body is thus obliged to make, to the general waste of tissue, affects also the muscular fibres of the blood-vessels, and the thinning out of their contractile cells by a degenerative process, leaving fewer of these for effective purposes, furnishes a clue to the general relaxation of the vascular channels, even under the enfeebled dilating power of the vaso-motor nerves, which also suffer in the general exhaustion, though from the composition of nervous tissue it might be inferred to do so to a less degree than muscular fibre, which is richer in albuminoid materials.

233. Whether the increased temperature in fever is owing to the rapid oxydation of accumulated effete materials, as has generally been believed,‡ or whether, according to Dr. Beale, it results from imperfect oxydation, associated with the undue increase of bioplasm,‖ is a question which does not affect our argument, and which may be left in abeyance here.

234. Nor need we here enter into the discussion as to whether what we call inflammation is a distinct and different process from essential fever as has been generally believed. Dr. Beale, however, regards both as depending on the same essential phenomena. "A fever may be looked upon as a general inflammation, while an inflammation may be correctly regarded as a local fever."§

What is certain is, that a "tightening" of the vascular channels by a diminution of their calibre, from a state of undue dilation, has a beneficial effect in languid conditions of the circulation, as we sometimes see in fever, while both in this state and in inflammation the contraction of the vessels lessens hyperæmia, lowers the temperature and favors a return to health. If the effect of our remedial measures in these diseased states be duly considered it will be found that a change in this direction is really what they tend in great part to bring about.

235. Thus the use of baths of a temperature lower by ten or twelve degrees than that of the body, cold packing, and cold effusion, are among the processes in use by modern science for the relief of the more urgent febrile symptoms. Doubtless here the excessive heat is largely abstracted from the body; but we know, too, that cold tends not only to paralyze the superficial vaso-motor nerves,

* Dr. Charles Murchison, F.R.S., Braith. Retros., July, 1872, pp. 17, 18, from Brit. Med. Jour., Feb., 1872, p. 175. † Dr. Sidney Ringer, Hand-Book of Therapeutics, p. 27. ‡ Dr. Murchison, Braith. Retros., July, 1872, pp. 17, 19. ‖ Disease Gems, pp. 328, 340, &c. § Medical Times and Gazette, Feb. 18, 1871, p. 183. Braith. Retros., July, 1871, p. 30.

but also by reflex action similarly impresses those more deeply seated, and thus both directly and indirectly favors contraction of the smaller vascular tubes which they supply. (§215.) Accordingly inflammation and its results are often prevented by the early application of cold,—as in surgical wounds,—if commenced sufficiently early. This argument is in no way affected by the well-known advantageous use of warm poultices in boils, whitlows, and other similar states; nor yet in the use of similar appliances in inflammation of internal organs, for here the cataplasms are applied, not with a view of averting the inflammatory process, but rather of hastening its termination by resolution, or if need be, by suppuration.

236. Among the leading remedies for certain forms of adynamic fever is quinine. According to Dr. J. H. Bennett, this drug, in large quantities, is a narcotic,* and Dr. Anstie, who has made the subject a special study, has declared that all the narcotics are paralysers, and exert this influence to a greater or less degree from the very first display of their physiological effects.

Narcotics act chiefly through the nervous system, which Dr. Periera also says they paralyze.† If quinine, in large doses, be a narcotic, one of its effects would then be to paralyze the vaso-motor nerves, and so to favor the contraction of the muscular fibres of the dilated blood-vessels in fever, and with this restoration of normal circulatory activity, to lessen those wasteful changes which, as we have seen, prove so spoliative to the tissues and so exhaustive to the organism. Probably in this way it may assist in dissipating the abnormally increased bioplasm, on which Dr. Beale lays so much stress, by hurrying it along in the current of the blood to be oxydized and eliminated.

This view of quinine as a paralyzer of the vaso-motor nerves finds some support in the fact, which experience has proved, that quinine acts on the uterus in parturition similarly to ergot by increasing the expulsive force; and we have seen, in the previous pages, evidence is not wanting to show that this is not necessarily brought about by any stimulating action on the spinal nerves, but taken in connection with previously mentioned facts, that ergot does this by paralyzing the motor or restraining nerves of the uterus. If this is true of ergot it is equally likely to be so of the similar action of quinine.

237. Again, "diffusible stimulants, as wine and coffee, are said to counteract the action of quinia."‡ If this fact be verified, it would add another link in the chain of proof; for diffusible stimulants increase nerve-power, at least temporarily; and if they antidote quinine, the latter must depress it. Besides, the effect of quinine in profuse sweating, as in phthisis, in passive bleeding, in undue

* Clin. Lec., p. 879. † Mat. Med., vol. I., p. 234. ‡ Dr. Ringer, Therapeutics, p. 523.

suppuration, profuse menstruation, spermatorrhœa, excessive secretion of milk, and profuse secretions generally, all of which it tends to arrest,* and its effect in favoring the manifestation of increased contractility of muscular fibre,† goes to confirm the same view: for increased secretion necessarily implies augmented blood supply, and when the former is arrested, the latter must be diminished. From all of which facts, it seems fair to conclude that quinine contracts the blood vessels, and from the arguments formerly adduced, we must infer that it does so under the same conditions as vascular contraction ordinarily takes place, namely, by depressing the vasomotor—dilating—nerves, so as to allow the inherent contractile power of the muscular fibre of the vessels to assert itself, and diminish their calibre accordingly.

Dr. Periera, however, furnishes us with contradictory evidence as to the effects of quinine on the system. Besides narcótic and sedative, stimulating effects have also been ascribed to it. Among these latter, are excitement of the vascular system, with increased frequency and fullness of the pulse.‡ Perhaps these different effects may depend on the condition of the persons in whom they were observed. Thus, in a phlegmatic individual, of flabby fibre, with relaxed vascular walls, and perhaps œdematous limbs, quinine, or digitalis, by "tightening" the vascular channels, may accelerate the flow of blood, quicken the circulation and improve the pulse, and so be considered a stimulant; while in a case of fever, where the vessels are also abnormally dilated, but less relaxed, quinine, by a similar effect on the vessels, may reduce their calibre, diminish hyperæmia, and so earn for itself the character of a sedative. So, also, if these effects be pushed to an extreme, and the arterial contraction be such as to deprive the nervous centres of a sufficient supply of blood to maintain their functional activity, such symptoms as "stupor, staggering, sudden falling down, convulsions, etc.,"‖ reveal the narcotic effects of the drug. And yet, in all these cases, the general action of vascular contraction is evident throughout.

But there must be something more in the action of quinine than simply contracting the blood vessels. Ergot does this effectually, and yet we never heard of ergot curing an intermittent fever. If, in addition to the effect just attributed to quinine, we add also antiseptic qualities, as regards the blood, we shall have fairly accounted for its complete powers in those febrile conditions in which its reputation is unrivalled.

The association of a stimulating action with quinine is so general, that it is refreshing to find such an authority as Dr. J. H. Bennett doubting that it is even a tonic. In reference to the frequency with which quinine is administered to convalescents and weakly persons, who get better under its use, he says, "whether this is

* Dr. Ringer, Therapeutics, p. 522. † Sundelin, Dr. Periera, Mat. Med., Vol. II, p. 684. ‡ Mat. Med., Vol.. II., p. 681. ‖ Dr. Periera, ibid, p. 680.

owing to the quinine, or would not have occurred equally well without it, is a matter very difficult to determine." So valuable (otherwise) and expensive a drug "should not be wasted in endeavoring to procure effects so very doubtful as the tonic virtues which have been ascribed to it."*

But, notwithstanding this high authority, there are other authorities, and numerous facts, which go to prove that quinine, in small doses, in appropriate cases, *does* exert a tonic influence, not only on digestion but on the circulation, in promoting warmth of the extremities. The same is true of small doses of strychnia, (Dr. Anstie) and to a less extent of opium. Here these drugs would appear to act more in the capacity of foods than otherwise; and by supplying some want in the system, tend to act as restoratives to normal nervous energy. In this way they may assist the musculo-motor and vaso-motor nerves in their functional task of controlling the muscular fibres to which they are respectively distributed, and so favor healthy activity in the muscles and normal circulatory activity in the blood vessels.

238. The action of alcohol, when properly understood, would appear to be entirely similar. Dr. Anstie has shewn that under certain conditions of the body alcohol acts as a food; not, indeed, in building up the tissues, but in preventing their waste. As soon as this range of its effect is passed, and the apparent "excitement" ordinarily, but erroneously, attributed to "stimulation," has begun, the process of paralysis of some part of the nervous circuit has already commenced.†

It does not require a clinical thermometer to prove that, in a state of ordinary health, alcoholic drink in large doses lowers the temperature. The most natural explanation that we know of this fact is in accordance with the views here propounded, and which is equally applicable to other narcotics, namely: by paralyzing to some extent the vaso-motor nerves, these become no longer able to restrain the contractile power of the vascular walls, which, as a consequence, have their calibre lessened, and with a diminished blood-supply the temperature of the surface and extremities is also reduced. The vaso-motor nerves are not the only ones functionally depressed. The *musculo-motor* nerves are also semi-paralyzed; as we see in the unsteady gait or the positive inability to stand or walk of one intoxicated. That portion of the cranial mass through which the mind exerts its powers of volition, is also, in some part, paralyzed. Hence the indiscretions of speech and act which so often attend this state, with which everyone is familiar.

These latter effects are never reached in fever or exhausting disease, even though many times the quantity of alcoholic liquors be administered which would induce this state of mental and physical

* Clin. Lec., p. 880. † See article on Alcohol, § 403 and § 459 of future pages.

paralysis in ordinary health. The vaso-motor nerve depression which would aid in setting the muscular fibre of the vascular walls free to contract, and so diminish the calibre of the dilated vessels, is only imperfectly induced; and beyond the trifling gain in this respect, the undoubted benefits of alcohol in these cases, must be sought elsewhere than through its action on the nervous system.

Opinions differ as to the manner in which alcoholic fluids produce beneficial effects in fever and exhausting disease. According to Dr. Anstie they do so by supporting the organism in the trial through which it is passing until the morbid process shall have passed over; and so far act as a substitute for food.* Dr. Beale denies any such *quasi* food action, and attributes the success of alcohol to its effects in checking the undue growth of bioplasm in the blood and tissues.† Perhaps both may ultimately be found to be right, in their general views.

Be this as it may, the difference between the effects of alcoholic fluids on the body, in health and disease, is very marked. So far as these effects display themselves through the agency of the nerves, the facts witnessed accord well with our theory; and that is the point which at present we wish to make.

THE HEART AND ITS NERVES.

239. Dr. Burdon-Sanderson informs us, that "nothing is as yet known either as to the anatomical distribution of nervous elements in the hearts of mammalia, or as to the functions which they perform." It is only in the frog, that "both have been made the subject of minute and repeated investigation."‡

One might suppose that in view of such a state of knowledge regarding the nerve-springs of the heart, speculation would remain in abeyance, or wait upon demonstration. Not so, however. An elaborate theory, of considerable complexity, has been arranged to meet the exigency of the current theory of vaso-motor innervation. This hypothesis we are about to state.

240. In the frog, motor ganglia have been demonstrated in the sinus venosis, auricles, and close to the auriculo-ventricular constriction, from which centre, a contractile wave extends to other portions of the heart.‖ It is inferred that motor ganglia also exist in the heart of man, and that the office of these is "to generate a force which sets the heart in motion.§

241. In order to account for the result of certain experiments, it has been necessary to assume the existence of another set of inter-cardiac ganglia, to restrain or "inhibit" the former; and also

* Stim. and Narcot., pp. 138, 233, 234. † Disease Germs, p. 424, etc. ‡ Handbook for the Physiol. Laboratory, p. 274. ‖ Ibid, pp. 274, 277. § Dr. Isaac Ott on the Action of Medicines, p. 66.

to regard these latter as connected with the terminations of the vagi in the tissue of the heart. The excitation of these inhibitory ganglia, or of the vagi, is regarded as equivalent to putting a brake on the heart; its pulsations being thereby rendered slower. If the excitation in question be strong enough, the first mentioned, or excito-motor ganglia, are overpowered and the heart is stopped.*

In addition to the foregoing, Schmeideberg has inferred the existence of "an apparatus seated between the endings of the pneumogastrics (vagi) and the inhibitory ganglia," the function of which does not appear. To show the grounds upon which this nervous appendage, or "apparatus," is supposed to exist, we condense the following from the recent physiological writer just quoted:

The vagi and inhibitory ganglia, if sufficiently excited, arrest the heart.

Muscarin, a fungoid poison, excites these inhibitors, and stops the heart.

Atropia paralyzes the excited inhibitors, and sets the heart going again.

Nicotin also paralyzes the vagi and the inhibitors, as atropia does, but unlike atropia, does not start the heart again.

Hence, in order to account for this peculiarity in the action of nicotin, it is inferred that its action is not expended on the inhibitory ganglia, but on the portion of nerve connecting the terminations of the vagi with these ganglia; that is, on Schmeideberg's "apparatus."†

The pneumogastric nerves are held to contain sensitive and motor nerve fibres, some of the latter of which retard, and others accelerate the heart's action; those which retard, being distributed to the inhibitory, and those which accelerate the heart, to its excito-motor ganglia‡

In addition to the foregoing, the heart is believed to have special "depressor" and special "accelerator" nerves, and is known also to receive branches from the sympathetic ganglion, or plexus, which surrounds the great vessels near their origin, and is correspondingly distributed.‖

The therapeutist who undertakes to trace the action of a drug upon these numerous and antagonistic ganglia and nerves, each working at cross purposes to the other, may well be excused if he gets bewildered. How the poor heart is able to continue its action so long and so regularly, from infancy to old age, amid such a host of rival and contending forces, may well excite surprise! That it maintains the even tenor of its pulsations, despite the "motors," "inhibitors," "depressors," "accelerators," and other nondescript "apparatuses," of which more are probably yet to come, is certainly

* Dr. Isaac Ott on the Action of Medicines, pp. 67, 96. † Ibid, pp. 67, 98. ‡ Ibid, pp. 83, 98, 99. ‖ Dr. Burdon-Sanderson, Hand-book for the Phys. Labor., p. 286, &c.

calculated to raise it in our esteem ; and considering the manner in which it is said to be beset on all sides, it deserves our warmest sympathy.

242. We have stated above the most recent theory as to the nervous mechanism of the heart. On such a subject we do not presume to have any opinion of our own to offer. But we are about to quote the facts and observations of physiologists themselves, with a view of ascertaining if the assumption of a much simpler mechanism would not equally account for the maintenance of the heart's action, and equally serve to explain the effects of drugs on that organ.

243. The pulsations of the heart begin, in early fœtal life, before there is any vestige of a nervous system ;* and they continue, in frogs, for hours and even days, under favorable circumstances, after the heart is removed from the body, and all its nervous connections are completely severed.†

It is evident, then, that the heart contains within itself the springs of its own action,‡ and that when properly nourished and its cavities supplied with blood, it is capable of fulfilling its proper functions without extraneous aid from the general nervous system.‖

244. The heart is composed of striated muscular fibres, having, like other similar structures, an inherent power of contractility. Dr. Carpenter suggests that the heart's fibres may possibly have an active force of elongation, as well as an active force of contraction.§ Rhythmical movements of contraction and extension take place in the intestinal villi, during absorption.¶ Alternate contractions and dilations occur in the vessels of the absorbent system also.**

Dr. Wharton Jones has observed a regular rhythmical movement in the veins of the bat's wing, "obviously depending on their inherent contractility ;" and a like movement is seen in the blood vessels of such of the lower invertebrata as have no heart.††

Are not the rhythmical contractions and relaxations of the heart of a character similar to those just noted, except that they are more important to the organism, are more elaborate in themselves, and are carried on upon a larger scale? And yet there is no pretence that these require for their continuance an elaborate and complex system of nerve-forces, such as has been inferred to exist in the case of the heart.

245. But while there are numerous facts which establish that the heart can continue its action, without extraneous aid from the nervous system, observations are not wanting to show that the heart's action is much modified by external nervous agency. Thus, section of the vagi causes it to pulsate faster. Faradization, which we claim to be equivalent to paralysis, of the vagi slows the heart, and

* Dr. Carpenter's Human Physiol., p. 324, &c. †Dr. Burdon-Sanderson, Handbook, &c., p. 274. ‡ Ibid. ‖Dr. Carpenter's Human Physiol., pp. 324, 470. §Human Physiology, p. 473, note. ¶Ibid, p. 440. **Ibid, p. 455. ††Ibid, p. 455, note.

if the current be strong enough, arrests it. Faradization of the mesenteric and splanchnic nerves has a similar effect. Such is also the consequence, at times, of a severe blow on the stomach, and of copious draughts of iced water.*

If, as we have seen, the general nervous system is not directly concerned in the continuation of the heart's movements, these facts shew that it is at least indirectly so: and this indirect influence is the object of our present enquiry.

We have Dr. Burdon-Sanderson's authority for the statement that the maintenance of the heart's action "is dependent on conditions which are contained within the heart itself."† If so, then, *these conditions must be dependent, in a large measure, on the normal nutrition of the heart*, and the integrity of its nervous and muscular fibre cells, since it is in these tissues alone that the motor power of the heart can exist under the circumstances.

Could it, then, be, that the heart's action is greatly depending on the regularity and sufficiency of the blood supply to the heart itself, and that the shutting off, or increase, of this supply, may account for the arrest or acceleration of the heart's movements?

It is true that the heart will continue to beat for some time, after division of all its large blood vessels, when its cavities are empty, and when its proper tissue can receive no blood or pabulum. But under these circumstances, the heart is not required to exert any force in propelling the blood. It contracts and dilates, from its inherent rhythmical action, but beyond this, *it does no work;* and the maintenance for a time of this minimum of motive power, may not be inconsistent with the minimum of contracting and dilating power which the muscle retains, temporarily, after blood and pabulum have ceased to reach it. This objection, therefore, though at the first glance a seemingly strong one, must be ruled out of the consideration of the enquiry just made.

If that enquiry could be answered in the affirmative, the question of the regulatory control of the heart's action would be greatly simplified.

246. The following remarks suggest themselves here, as tending to support such an affirmative answer, namely: that *increased blood supply to the tissue of the heart, nervous and muscular, tends to increase its functional power, and that diminished or arrested blood supply to the heart tissue, tends to arrest its action.*

(a.) Such a supposition would be quite consistent with what is witnessed in other muscles and organs.

(b.) When the animal is killed by "pithing," the heart's action ceases much sooner if the coronary arteries have been tied, than when they are left untouched, as has been proved by the experiments of Dr. Erichsen.‡

* Dr. Burdon-Sanderson, Hand-book Phys. Labor., pp. 282, 285. †Ibid, p. 274.
‡Dr. Carpenter's Physiol., p. 324.

(c.) Faradization of the vagi and abdominal (sympathetic) nerves, arrests the heart. These nerves of the abdominal viscera contain vaso-motor fibres,* and the effect of the faradization on either sensitive or vaso-motor nerves, may be assumed to do in this case what it invariably does elsewhere, that is to contract the muscular coats of the arterioles, lessening or obliterating their calibre, and occluding blood supply. The coronary arteries necessarily share in this effect, resulting from an action taking place in their vicinity and on nerves with which their own vascular nerves are intimately associated.

If shutting off local blood supply from the heart tissue, depriving its nerve and muscle cells of receiving the due share of pabulum, on which their functional activity depends, will cause the arrest of the heart's action, then the very conditions for such arrest are here present.

(d.) The paralyzing effects of a blow on the stomach or of copious draughts of ice water, acting on the same nerves would produce similar effects to those just noted, arresting the heart in a similar manner.

(e.) Section of the vagi is stated by Dr. Carpenter to have but little effect on the heart's action ;† but other physiologists find that in the dog, rabbit, and probably in man, but not in the frog, division of the vagi is followed by accelerated action of the heart.‡ Here, cutting the vagi may be equivalent to irritation of both portions of the divided nerve, as section of nerve tissue is held to be in other cases by physiologists, of which we have already furnished examples. (§ 204.) This irritation, directly or reflexly increasing the power of the local vaso-motor cardiac nerves, would necessarily dilate the cardiac arteries, causing additional blood to permeate the tissue of the heart, and consequently inducing greater rapidity of action.

In support of this view, it may be added, that section of the vagi evidently results in increased arterial dilatation of the pulmonary vessels; for animals subjected to this operation die with all the appearances of congestion of the lungs.‖ As this is a cardiac as well as a respiratory nerve, increased blood supply to the heart tissue from its section, seems probable also, although from the differences in the structure of the two organs, the results of such hyperæmia would be much more likely to pass unnoticed in the heart than in the lungs.

(f.) Certain drugs, notably the narcotics, which arrest the heart, produce general arterial contraction, in which the coronary arteries doubtless share. The effect is similar to that already noted in the other cases of heart arrest: diminished blood and pabulum, starving the nerve and muscular cells concerned in the production of its motor power, and so bringing this wonderful piece of mechanism to a stand-still, in a manner which will probably not be understood

* Dr. Burdon-Sanderson, Hand-book, p. 258. † Human Physiology, p. 469. ‡ Dr. Burdon-Sanderson, Hand-book, &c., pp. 281, 285. ‖ Ibid. p. 318.

until the mystery of life itself is unveiled. Whether the heart is arrested in a contracted or dilated state, depends probably to a great extent upon the previous, or later, arrest of respiration and blood circulation in the lungs.

(g.) That the heart should be thus dependent upon its own vaso-motor system for a constant renewal of its energy, is natural and consistent, in an organ whose action is well nigh perpetual, and whose pauses are so brief and instantaneous as presumably not to suffice to permit of the accumulation of force, such as we find in the uterus and other organs. Its position, on this view, seems like that of the poor labourer, living "from hand to mouth;" exhausting its power as fast as generated in its cells, and in danger of suspending its activity should the continual production of its energy cease for lack of the pabulum on which it is fed.

247. On a subject so difficult and obscure it will not do to dogmatize: but some less complicated theory of the heart's innervation is needed than the one quoted above from the authorities. And some more consistent view of drug action is needed than can be supplied by a theory which requires one cardiac nerve to be excited and another paralyzed, or both of these effects to occur, in different parts, or in different fibres of the same part, of an individual nerve, at the same time and by the same drug.

Here is an illustration in point, taken almost at random from a recent work, treating of the physiological action of medicines. Of belladonna it is said, "It paralyzes the motor nerves in frogs, at the same time that it excites the spinal cord; after they recover from the motor nerve paralysis, the tetanic symptoms of spinal stimulation appear."* Equally conflicting and confusing statements might be multiplied, from recent writers on drug action. There is, however, strong ground for believing that drugs which paralyze do not excite any part of the nervous system; but that their action is uniform throughout.

248. Most of the recent observations as to the action of drugs on the heart and its nerves, have been made upon animals which are known to be very differently affected by the same drug; and under circumstances which justify caution before accepting the conclusions arrived at as final.

Thus, the animals experimented on are usually first paralyzed with curare, woorari, or narcotized with chloral, to prevent struggling, from the torture of the processes to which they are subjected. The spinal cord in some cases, in others the leading nerve trunks, are then cut, rendering artificial respiration necessary. A leading artery in the neck or limb is connected with the tube of a mercurial manometer or kymograph, to test the arterial pressure. Atropine, muscarin, or some other drug is then injected, and not only the

* Dr. Ott on the Action of Medicines, p. 138.

blood pressure, but the effect of the drug on undivided nerves is inferred, and an excitation, or paralysis, of motor, inhibitor, depressor, accelerator, sensory, or sympathetic nerves duly recorded accordingly. Here is a quotation, setting forth in the language of the operator, the *modus operandi* of an experiment of this kind :—

The experimenter, "In a cat, divided the vagi, gave woorari, employed artificial respiration and injected sanguinarina. He then irritated [faradized] the sciatic nerve, and found toward the end of the poisoning that a strong current only elevated the blood pressure a few millimetres, whilst normally the rise should be many. Now this want of increase of arterial pressure might be due to a paralysis of sensory fibres or of sensory ganglia, no impression being conveyed to the vaso-motor centre. To decide, he gave another cat woorari, screwed Ludwig's gimlet electrodes into the occiput and atlas, and divided in the neck the vagi, sympathetics [both sides] and depressors, artificial respiration being kept up, and irritated the vaso-motor centre in a direct manner with an electric current, and found that this caused no elevation of blood pressure, [shewn by the manometer connected with an artery,] hence the want of rise was not due to a want of transmission through the sensory communication leading to to this centre. Other "irritations" on other nerves, or centres, further cleared the ground, and, we are assured, "completed the train of reasoning that sanguinarina paralyzes the main vaso-motor centre."*

Now, there must be great sources of fallacy here, because with the motor nerves paralyzed by woorari, so many important nerves cut, the gimlet electrodes impinging on the brain and cord, and then the paralyzing effects of a faradic current super-added, a terrible assault must have been made upon the integrity of the nervous centres, even if the sanguinarina had not been administered at all. And the very complexity and contradictory character of the conclusions arrived at, point strongly to a fallacy somewhere in the "train of reasoning."

249. Let us now return to the suggestions we have made as to the effect of cardiac vaso-motor regulation of blood supply and pabulum, to the heart tissue, through the coronary arteries, as affecting the heart's action or arrest. The phenomena of drug action on the heart appears to point to a general rule, that *all drugs which cause increased circulatory activity in the cardiac muscle, increase the action of that muscle: while on the contrary, drugs which shut off blood from the cardiac tissue, by contraction of its coronary arteries, tend proportionately to arrest the heart's movements.* When these drugs cause previous arrest of respiration, the heart is arrested in diastole and its right side at least, is full of blood. When the heart dies first, it is empty and contracted. This is well seen in the case

* Dr. Ott on the Action of Medicines, pp. 85, 86.

of frogs, poisoned with digitalis, where for hours before the general death of the body, the heart remains rigidly contracted; as Dr. Harley has said, "a dead heart in a living body."*

It would also appear as if the effect of paralysis or excitation of the leading nerve trunks, cranio-spinal or sympathetic, in so far as these affect the heart's action, operate through the direct or reflex influence they exert over the cardiac vaso-motor nerves, in increasing or diminishing blood supply to the heart itself.

250. It is not pretended that this view of the manner in which the heart is controlled, is proved, or that it is more than suggested; but if such a view were probable, as it appears to be, the elaborate and antagonistic nervous excitors, inhibitors, accelerators, depressors and "apparatuses," might be dispensed with, and the cardiac movements contemplated under circumstances very much simplified, and approximated to that of other rhythmical movements of contraction and dilation witnessed elsewhere in the organism.

Since the foregoing was written, we have been enabled, through the kindness of a medical friend, to peruse an account of a thrombosis of one of the coronary arteries, in the practice of Dr. Hammer, of St. Louis, U. S., in a translation from the "Gazetta Medica Italiana," made by Joseph Workman, M. D., of Toronto,† which furnishes a strong corroboration of the views expressed above. We condense from this paper as follows:—

The patient was a man thirty-four years of age, of robust constitution, but subject to articular rheumatism, from an attack of which he was recovering, when he suddenly fell into a state of collapse. Half an hour afterwards his pulse was forty in the minute, and during the next few hours it declined to twenty-three, then to sixteen, and finally to eight beats per minute. During this time the lips became livid and cyanotic, the face pallid, and the skin was covered with a viscid perspiration. There was dyspnea, but no pain.

Careful auscultation of the heart revealed the fact that after each contraction, lasting one second, a clonic spasm occurred in the heart's tissue, lasting five seconds, accompanied by an audible fremitus. Then followed a pause of absolute rest, of two seconds, after which the normal contraction, spasm and repose followed, and so on in series.

Dr. Hammer formed the opinion that the symptoms were due to thrombosis of one of the coronary arteries, on the grounds that if both were occluded the heart's action would be sooner arrested; and also from the peculiar action of the heart, which he attributed to paralysis of half the organ. The patient survived nineteen hours: and on examining the heart, the right auricle and ventricle were

* Dr. R. Hughes, Pharmacodynamics, p. 261. Dr. Ringer's Therapeutics, p. 405.

† This paper was since published in the Canadian Journal of Med. Science for November, 1878, p. 352.

found filled with coagulated blood. The tricuspid and semi-lunar valves were intact, and the cavities generally normal. But in proximity to the right semi-lunar valve of the aorta, and extending from thence to the commencement of the corresponding coronary artery, and quite occluding the latter, was a mass of whitish-yellow coagulated fibrinous deposit. Within the base of the coronary artery this fibrinous mass was very much discolored, more dry, interlaced, and of a greyish-red color.

The aortic valves were not thickened, but the posterior one had coalesced over a small space with the right and left valves, and in the immediate vicinity whitish excrescences were found, from the apex of one of which a slender filament was traced to its connection with the clot, giving rise to the idea, that while at first floating free, this had furnished a rallying point for the accumulation of coagula, till by its weight it had assumed the position mentioned. Thus the diagnosis during life was fully confirmed.

We are glad to be able to add this very interesting fact, of the existence of which we were unaware when the foregoing pages were written. It shows how dependent the heart's action is on the local nutrition of its own nervous and muscular tissues, and how important a part the coronary arteries play in the process. Apparently just in proportion as the obstruction in the coronary artery increased, the heart's action failed, as indicated by the diminished frequency of the pulse, until it finally ceased entirely. The case is peculiarly valuable owing to the absence of other complications, and others of a similar kind will be awaited with much interest.

CHAPTER VIII.

THE IRIS AND PUPILLARY CHANGES.

251. The theory here advanced is adapted to explain the contraction or dilatation of the pupil from disease and drug action. Is the iris a muscular structure, composed of radiate and circular fibres, or is it more properly to be regarded as an erectile tissue, is a question which is discussed at some length in Note B of Dr. Anstie's work on Stimulants and Narcotics. It is there shewn that the muscular theory has serious drawbacks, among which is the fact that in man the alleged circular fibres have never been clearly made out, and have been rather a matter of faith than of demonstration. Their existence has been denied by many competent anatomists, and we owe the references made to them probably in a great degree to the exigencies of this theory.

252. Dr. Fraser, of Edinburgh, shows that on this theory the pupil may be influenced in at least six different methods. 1. By cerebral irritation. 2. By cerebral depression. 3. By spinal irritation. 4. By spinal depression. 5. By a combination of cerebral irritation with spinal depression. 6. By a combination of cerebral depression with spinal irritation. In carrying out this scheme, it is necessary to assume that some drugs both excite the cranial nerves and depress the spinal nerves, and *vice versa*. Thus the dilatation of the pupil in poisoning by prussic acid is accounted for by Dr. Fraser, by declaring "that prussic acid irritates the cord and depresses the brain, and thus simultaneously paralyzes the constrictor, and excites the dilator fibres of the iris."*

Recent dissertations on the physiological action of drugs abound with assumed diverse effects of the same drug, not only on different nerves, but even on the same portions of particular nerves, which are excited, paralyzed and re-excited, apparently at the dictum of the experimenter, in a most extraordinary manner.†

253. Dr. Anstie has pointed out that such a presumed alternate excitation and paralysis by a drug is quite inconsistent with the universal and inevitable sequence of narcotic phenomena; that *all* the phenomena of narcosis, whatever may be their external appearance, result from devitalization of that part of the nervous system which is immediately concerned in their production; that the process of narcotism is *an uniform one*, and tends entirely in the direction of nervous death.‡

"On the other hand the *erectile* theory of iridal movements has received a most important reinforcement within the last few years." Besides other facts bearing on this theory, M. Rouget has established the continuity of the vascular elements of the iris with those of the choroid, the continuity of the muscular fibres of the iris with those of the ciliary muscle, that the superficial appearance of radiation in the iris by no means indicates the course of the muscular fibres, which are not arranged in a regularly radiating direction, but obliquely, so that they intersect at various points in their progress from the pupil to the corneal edge. These, and other considerations, induced Dr. Anstie to conclude "that the evidence greatly preponderates in favor of the view that the iris is an erectile tissue; an offshoot of the choroid tissue, and that its muscular elements subserve merely the same office as that of the like elements in erectile structures elsewhere."‖

Dr. Anstie, in accordance with the erectile theory, holds that a contracted pupil implies an iris distended with blood, and so, projected towards the centre, from its ciliary attachment: while a dilated pupil equally implies an anæmic or empty condition of the

*Dr. Anstie, Stim. and Narcot., p. 409. †See Dr. S. Ringer's Hand-book of Therapeutics, and Dr. Ott on the Action of Medicines. ‡Ibid, pp. 407-8. ‖Ibid, p. 408. Also Dr. C. B. Radcliffe, Lectures on Epilepsy, Paralysis, etc., p. 208.

iridal vessels, which permits the condensation of the tissues of the iris, and consequently a dilated pupil. In extreme narcosis, the contraction of the vascular walls, which thus empties them of blood and dilates the pupils, he regards as an early *rigor mortis* of their muscular coats "which often happens locally before the death of the organism."*

But dilatation of the pupil must be accounted for under other symptoms than these mentioned, that is, under no very extraordinary circumstances during life, and when the presence of *rigor mortis* cannot be entertained.

Dr. Anstie does not follow up the hints he has given elsewhere, as to the independent contractile power of muscular fibre; and consequently we are left to apply the theory we have been advocating, without any further aid from the authorities, who seem time and again almost to assert, and yet avoid it.

254. Then, under the theory we suggest, how are the pupillary changes accounted for? Take belladonna, which paralyzes the vaso-motor nerves of the eye, if applied locally, and of the brain, including the eye, if administered internally: and by thus suspending the power of the dilating vascular nerves, permits unrestrained contraction of the muscular walls of the vessels, emptying them of their contents. The result is a diminution in the bulk of the iridal erectile tissue, which gathers itself towards its attached margin, leaving a larger pupillary opening. That belladonna acts in the way stated, in so far as a diminution of the calibre of the vessels is concerned, is proved by its general action on glandular structures, in arresting secretion; for, according to Dr. Radcliffe's physiological law, diminished blood supply has arrested secretion as its necessary sequence, just as vascular fulness is attended by augmented secretion.†

So, also, of all other drugs which dilate the pupil. This effect is at once produced by opium in the cat; but not so in man, where hyperæmia of the brain is first set up, but in the last stage, when the vascular nerves are paralyzed and can no longer restrain the contractile power of the muscular walls of the vessels, these last attain the mastery, contract the arterioles, shut off the entrance of blood to the iris, which passes into the state produced earlier by belladonna, prussic acid and other narcotics, shewing the iris reduced to a mere ring, bordering its ciliary attachment, with widely dilated pupil. Precisely the same result is seen in the fatal narcotism of chloroform.

255. On the other hand, those drugs which cause contraction of the pupil, reinforce vascular nerve power, either locally, when dropped into the eye, or generally, when administered internally; dilatation of the vessels follows; a state of local or cranial hyper-

* Dr. C. B. Radcliffe, Lectures on Epilepsy, Paralysis, etc., p. 409. † Lectures, etc., p. 238.

æmia is set up; the erectile tissue of the iris is full of blood, in consequence of which its free border is pushed further away from its attached margin, and the pupillary opening is proportionately closed. (§ 387.)

256. It may be objected, that profound paralyzers of motor nerves, like calabar bean,—which contracts the pupil,—are very unlikely agents to increase vaso-dilating nerve-power; but it must be remembered that calabar bean contracts the pupil only when locally applied;* (§ 387) and that other equally profound paralyzers —as aconite—act as local irritants, and set up hyperæmia in the surfaces with which they first come in contact. When this is the case on surfaces like the mouth, throat, etc., a similar action is to be anticipated in the more sensitive membrane of the eye.

Thus, then, on the erectile theory, a dilated pupil coincides with an empty condition of the blood vessels of the eye, or of the brain, in which case the eye is included, while a contracted pupil coincides with a state of hyperæmia, which may be local as regards the eye, or general, including the eye with the brain.

And these conditions of the blood vessels, on the theory we suggest, are in turn depending on the relative preponderance of either of the two antagonistic forces which regulate the calibre of the vessels. Give vaso-motor nerve-force the preponderance, and the vessels dilate, contracting the pupil; allow the muscular fibre of the arterial walls the mastery, and the vessels are contracted, the iris shrinks, and the pupil is enlarged.

257. Let us now enquire how far the facts of experimental physiology agree with the theory of pupillary changes, just suggested.

Contraction of the pupil results from the following conditions:—

1. The undulations of light, impinging on the retina, excite vibratory sensations, which are transmitted through the optic nerve to the corpora quadrigemina, from which centre they are reflected back along the motor oculi (third pair) to the eyeball, where the latter nerve supplies motor nerve-force to the ciliary ganglion and most of the muscles of the eyeball.† As the ciliary ganglion (sympathetic) supplies vaso-motor nerve filaments to the eyeball, including the iris, the excitation of which would dilate the iridal vessels, expand the iris, and proportionately close the pupillary opening, this fact is quite in accord with our theory.

2. Section of the optic nerve, or irritation of it, as with a needle, causes the pupil to contract.‡ Here, the reflex action is similar to that caused by the vibrations produced in the nerve by light, only more intense, owing to the irritation being greater. As in the former case, our theory is equally applicable.

3. Faradization of the third pair contracts the pupil.‖ In former pages we have seen how the faradic current, applied to a motor

* Dr. Anstie, Stim. and Narcot., p. 409. †Dr. Carpenter's Human Physiol., pp. 685, 697. ‡Ibid, p. 715. Dr. Dalton's Phys., p. 436. ‖Dr. Carpenter's Phys., pp. 831, 880.

nerve, causes rapid contractions and relaxations of all the muscular parts to which the nerve is distributed, with determination of blood to the part, etc. The motor oculi is distributed to all the muscles of the eyeball, except one. The vibratory activity set up in these muscles, and doubtless also in other fibrous structures of the eye, fully accounts for the increased local hyperæmia of the iris, and consequent contraction of the pupil. Here, again, our theory is consistent with the facts.

4. Mechanical irritation of the third pair contracts the pupil.* This is simply the equivalent of the first and second facts noted, only that the irritation is direct instead of being reflected from the sensitive optic nerve through the nervous centre of vision. The same effect on the vessels is to be noted as formerly, with a similar accordance between the facts and our theory.

5. Section of the cervical sympathetic nerve produces contraction of the pupil, with increased afflux of blood to the head and eyeball.† We have seen in No. 2 of the present series, that section and irritation of the optic nerve are equivalent as to their effects. In a previous page, we have sought to shew that section of the cervical sympathetic was attended by irritation, and not by paralysis, of the vaso-motor nerves of the head, (§ 203) and have quoted Goltz, Dr. Dalton and others, in support of that view. Whether that position be sustained or not, the hyperæmia of the eye, in the case, is palpable, and this state of the iris is consonant with a contracted pupil, and so far sustains the erectile theory, and if, as we have argued, and as is the case after section of the optic nerve, the cervical sympathetic is irritated and not paralyzed, then our theory also is in perfect accord with the facts of the experiment. We may add, here, that Dr. Anstie, in alluding to the experiment in question, does not regard the nerve as paralyzed, for he says "such a procedure by no means cuts off all nervous influence upon the iridal vessels: the vitality of the nerve beyond the section, at least, will remain in great part unimpaired, to say nothing of possible communications with the centres by circuitous routes. Under such circumstances, the condition of the iridal vessels is by no means one of inactivity; on the contrary, the blood circulates through them with increased force at the same time that their calibre is enlarged. Contraction of the pupil results."‡

6. Irritation of the corpora quadrigemina contracts the pupils.‖ This is a parallel case to Nos. 1, 2, and 4, excepting that instead of the sensitive or motor nerve, it is the optic nerve centre itself that is irritated, and the irritation produces similar results in dilating the vessels, and equally accords with our theory.

7. Section of the fifth pair, after all the other nerves of the eye have been divided, contracts the pupil. The same effect is attri-

*Todd and Bowman, Physiol Anat., p. 475. †Dr. Brown-Sequard's Lectures on Cent. Nerv. Syst., p. 140. ‡Stim. and Narcot., p. 408. ‖Dr. Carpenter's Physiol, p. 708.

butable to faradization and to mechanical injury of the fifth pair, under the like condition of other nerves, only in a lesser degree. The ophthalmic branch of the fifth pair is generally held to have purely sensitive fibres, but its long branch to the ciliary ganglion is believed to contain motor fibres passing up from the cervical and dorsal spine to the iris.* Division or irritation of these in the cilio-spinal region affects the iris also; but it would be tedious to follow all the conditions in question, and unnecessary to do so, since injury to leading nerve trunks of the eye, by exposure and section, or irritation, is quite sufficient to account for a state of hyperæmia of the iris and its surroundings, in the way our theory suggests, and this being the case, our object in applying these physiological tests is obtained.

258. *Dilatation of the pupil* is produced by the following physiological conditions, which appear to be fewer than those causing contraction:—

1. Faradization of the cervical sympathetic dilates the pupil.† This nerve, differing materially both in its structure and functions from a cerebro-spinal nerve like the motor oculi, faradization produces, of course, a different effect. Instead of causing spasmodic contractions, alternated with relaxations, as in the case of motor nerves, the effects of faradization on it will be seen in the altered calibre of the arteries which it supplies. We have already claimed that its functions so far as the vascular nerves are concerned, are paralyzed, by faradization, and that as a consequence the muscular fibres of the arterioles being no longer restrained from exerting their inherent contractile power, the calibre of the vessels is reduced, and in the case of the iris, its tissue is collapsed in the manner already described, causing an enlargement of the pupil. Here, the erectile theory and our own, are in full accord with the facts quoted.

2. Section of the third pair causes the pupil to dilate.‡ The ciliary ganglion is so small, that as a depot, or "magazine of nerve power" it is soon exhausted. Its chief, and perhaps only supply of motor nerve-power, as is well-known, is derived from the short branch of the third pair, which enters it. When the third pair is cut, this channel for reinforcing its dilating nerve-force is cut off; and the muscular fibres of the walls of the iridal vessels, no longer restrained by the ciliary (sympathetic) vascular nerves, act as they always do in like circumstances, and with similar results, diminishing or obliterating the calibre of the arterioles, contracting the width of the iridal tissue and correspondingly enlarging the pupil. Surely no theory could meet the circumstances of the case more fairly or naturally.

3. Hœmorrhage into the ventricles of the brain is attended by a dilated pupil.‖ What more probable explanation of the fact than

* Dr. Carpenter's Physiol., p. 684. † Ibid, p. 881. ‡ Dalton's Physiology, p. 522.
‖ Dr. Bastian, Paralysis from Brain Disease, p. 234.

paralysis of dilating vascular nerve-power, attended by arterial contraction, emptying the vessels of the iris, producing retraction of its free margin and enlarged pupil.

4. Poisoning by belladonna, prussic acid, opium—last stage,—chloroform, ditto, and by other drugs, finds the pupil dilated. In some of these cases the vaso-motor nerves seem the last to succumb; but when their paralysis is at length complete, and their dilating power is at an end, the non-vital, and consequently non-paralyzed contractile power of the arterial coats, reduces their calibre, blood is shut out out from the iris to accumulate in the venous sinuses or elsewhere, the erectile tissue of the iris retracts upon itself, and, as a consequence, the pupil is dilated.

Thus, it will be seen, the theory here suggested is applicable to the advanced ideas of modern research, as to the nature of the iris, and to the condition of its vessels, on which its contraction or dilatation depends; as well as to the results of experimental physiology, which may be held to be crucial tests for any theory purporting to explain these phenomena.

CHAPTER IX.

HOW THIS THEORY ACCORDS WITH CERTAIN IRREGULAR CONTRACTIONS OF THE ALIMENTARY TUBE, INCLUDING THE VARIOUS KINDS OF VOMITING.

259. Are the irregular muscular contractions of the œsophagus and stomach, causing regurgitation and vomiting of food and drink, depending on increased motor nerve-force, acting reflexly, and "stimulating" the muscular walls of these organs to contract, in accordance with the accepted theory, or, are the phenomena in question more consistent with an assumed paralysis of the motor nerves, and the absence of nerve-force, leaving the expulsive efforts in question to depend entirely on the inherent contractile power of the muscular walls of the œsophagus and stomach?

We propose to endeavor to shew that the latter of these queries must be answered in the affirmative; that here, as elsewhere, nerve-force and muscular contractile power are direct antagonists, and that the latter displays its characteristic action, when the former is so modified that it may be said to be paralyzed or suspended.

260. The nervous supply of the œsophagus and stomach, as is well known, is derived from the pneumogastrics, which contain both sensitive and motor fibres, and from the branches of the solar plexus, (sympathetic), which plexus is partly composed of the splanchnic nerves.

These latter are known to contain the vaso-motor nerves, of the stomach ;* and as besides these, the sympathetic nerve supplies the abdominal viscera with motor and sensitive nerves, the stomach doubtless receives a share of these latter nerves also from the same source.

261. We now proceed to consider the dependence, or otherwise, of the irregular contractions of these viscera, on nervous agency.

Dr. Dalton states that after division of the pneumogastric nerves, food and drink are swallowed as before, but accumulate in the lower and middle part of the œsophagus, and "owing to the paralysis of this canal, they are not conveyed into the stomach," and "in a few moments are suddenly rejected by a peculiar kind of regurgitation."†

Now, if the muscular walls of the œsophagus were paralyzed, as Dr. Dalton, and others, assume, it would be a mere flaccid tube, and could neither offer resistance to the passage of food and drink, nor could these be "suddenly rejected," as appears to be the case. The symptoms recorded point rather to constriction of the lower end of the œsophagus, resulting from the withdrawal of nerve-force and the consequent unopposed contraction of the muscular fibres concerned : just as in the extinguishment of nerve-force by death, other tubes, including the arteries, lacteals and intestines pass into a state of contraction.‡ Indeed, the "paralysis" in all these cases, appears to be that of nerve-force, and not of muscular fibre.

262. Dr. J. Reid reports the section of the vagi in a rabbit, which had been kept fasting for sixteen hours previously, and was then allowed to eat parsley. It died in five hours. The œsophagus was found full, and the stomach also, *but not distended.* A good deal of the parsley had passed into the trachea and bronchial tubes, and even into the minute air cells of the lungs.‖ This experiment is quoted as a proof of the paralysis of the muscular walls of these organs. But the undilated stomach, under the circumstances, points rather to a contracted state of its muscular walls, which bear witness to the characteristic power of muscular fibre, when its antagonizing nerve-force is withdrawn.

263. Dr. Carpenter refers to this subject by stating that "if the pneumogastric be divided in the rabbit on each side, above the œsophageal plexus, but below the pharyngeal branches, and the animal be then fed, the food is delayed in the œsophagus, which becomes greatly distended.§ That is to say, the upper part of this tube, where the motor nerves are still intact, behaves in a normal manner, on the entrance of food ; while in its lower part, which has been deprived of the influence of nervous agency, and nerve-force is

* Dr. L. Brunton, Hand-book for the Phys. Labor., p. 493. † Physiology, p. 473. ‡ Dr. Carpenter's Physiology, pp. 454, 334. ‖ Drs. Todd and Bowman's Phys. Anat., p. 491. § Phys., p. 404.

consequently in abeyance, the muscular walls pass into a state of contraction, and so constrict the calibre of the tube as to arrest the further passage of the superimposed injesta. Could any stronger proof be demanded in justification of the truth of our theory?

Dr. Carpenter, however, further remarks, "that the action of the cardiac sphincter is reflex, and is dependent on the 'nervous circle' furnished by the pneumogastric nerves and their ganglionic centres, would appear from the fact that when the trunks of these nerves are divided, the sphincter no longer contracts, and the food regurgitates into the œsophagus."* This statement is hardly quite in accord with the previous quotation. And yet, both may be strictly true, for, as this distinguished physiologist adds, "The re-opening of the cardiac orifice, *on pressure from within*, is one of the first of that series of reversed actions which constitutes the act of vomiting."† May we not see the explanation of the opening of the cardiac sphincter and the regurgitation of the food from the stomach, in the contraction of the muscular coats of the latter, liberated from the restraint of nerve-force by section of the vagi; thus occasioning the "pressure from within," which could not occur if the organ were paralyzed: just as the contraction of the lower third of the œsophagus, under similar conditions, caused the sudden ejection of the food upwards into the mouth, as stated by Dr. Dalton?

264. In the very animal referred to in these experiments, Dr. M. Hall found that "the simple contractility of the muscular fibre [of the œsophagus] occasions a distinct peristaltic movement along the tube, *after its nerves have been divided*, causing it to discharge its contents when cut across."‡

265. We have further to quote as follows:—"The office of the gastric branches of the vagi nerves, appears, from Dr. Reid's experiments, to be, chiefly, *to control* the movements of the muscular coat of the stomach. Mechanical irritation of these nerves causes slow and vermicular contractions of this tunic. *Section of them may cause in the first instance vomiting* and loathing of food."‖ The reader will please note the significance of the words we have placed in italics, and also the further fact that "irritation" by no means necessarily implies stimulation, and is much more likely to be equivalent to paralysis; for the molecular arrangements which determine the relation of nerve-force to muscular fibre, when deranged, are temporarily overthrown, as in the action of electricity, and while so deranged—that is while the irritation lasts—may be held to set muscular fibre free.

266. The effect of electricity, here, as elsewhere, is to cause universal contractions of muscular fibre, as is seen in the glottis œsophagus and intestines. If what we have already urged, on the paralyzing effects of this agent on nervous tissue, be true, this fact,

*Physiology, p. 404. † Ibid. ‡ Ibid. ‖ Drs. Todd & Bowman's Physiol. Anat., p. 493.

taken in connection with the preceding physiological proofs can leave no reason to doubt the antagonism between nerve and muscle; or that the irregular contractions of the stomach producing vomiting, occur, not through the increased "stimulus" of nerve-force on muscular fibre, but solely through the independent contractile power of the muscular walls concerned in the process.

267. Those who insist on maintaining the popular theory of the mode in which vomiting occurs must be prepared to shew that the drugs, methods, or agents, which induce vomiting, are such as, from their nature or quality, tend either to increase the physiological activity of the cells whose function it is to elaborate nerve-force, or in some way to call into action increased motor nerve power from the ganglionic centres, which is thence conveyed as a "stimulus" to the muscles to be acted on.

268. Now, a fall, or a blow on the head, occasioning temporary "shock," or concussion, is very likely to be attended by vomiting. Is nerve-force here augmented, or is an increased stimulus evolved from the central ganglia, by which the gastric muscle is made to contract? Surely this is a condition of which the very opposite state of nerve activity may be predicated.

Again, take the deathly nausea and utter prostration, bodily and mental, occurring during sea-sickness; or the perhaps equally familiar effects produced on the tyro who smokes his first pipe of tobacco, and let him who has fully experienced either, say if these states are favorable to an increased development or discharge of nerve-force; or if they are not, on the contrary, much more suggestive of a condition of the gastric nerves bordering on paralysis.

Or, spread out before us a list of the accredited emetics, and indicate which of them, in emetic doses, would be thought of as a stimulant to nerve-force; or which we would dare to administer, in such doses, in states of the system where exhaustion was predominant, and in which we desire to restore the flagging energies. We have said, "in emetic doses," because it is in such doses that the nervous circle of the pneumogastrics and other motor nerves engaged in the reflex act, are said to receive the "stimulus" which produces emesis.

269. Those drugs, ipecacuanha, tartar emetic, &c., which cause emesis when introduced into the blood from any part of the system* are known as "specific" emetics. Dr. Headland classes them as special sedatives, and declares them to be nervous depressants, the effect of which is directly of an opposite kind to that of stimulants.† These, then, cannot produce emesis by means of a reflex action of a "stimulating" kind. See Apomorphia, § 325.

The other and larger class of emetics, of the primarily irritant kind, as sulphates of zinc and copper, common salt, mustard, &c.,

* Dr. Headland, Action of Medicines, p. 106. † Ibid, p. 296.

do not cause emesis when introduced into the system, elsewhere than in the stomach, as do the former. Inasmuch as when taken into the stomach, they can only irritate its own surface, by contact, and do not directly impress the diaphragm or other abdominal muscles, which are also called into action in vomiting, it is held that these extraneous muscles must be acted on reflexly through the same nervous channel as in the former case, namely, the pneumogastrics and motor nerves of expiration.*

270. There can hardly be any doubt that this reflex impulse is also of a depressing kind. As already pointed out, an "irritant" is by no means to be regarded as necessarily producing stimulation. Dr. Headland defines the term "irritation," used in this connection, as "a violent dynamical action on nerve and muscle, differing both from the healthy agency of a stimulant and the chemical operation of an astringent medicine."† A "dynamic" impulse of this kind may so affect a nerve as to disturb those mysterious molecular changes, by which nerve-force operates, and this perturbation may so affect the relations between nerve-force and muscular fibre as to release the latter from restraint. Indeed, it seems certain that both what we call increased nervous activity, and paralysis, are simply effects of the differences in the mode of motion of the molecular particles of which nerve tissue is composed; such changes having their starting point from the terminal filaments of sensitive nerves, and from the central or ganglionic origins of the motor.‡

271. The only drug of this class of emetics, about the non-stimulating action of which any doubt need to exist, is mustard; which, at first sight would appear to be an excitant. Dr. Ringer, however, points out how slight an effect this substance produces on the stomach, compared with its action on the skin; and that it does not increase the gastric secretion.‖ Now, as this secretion is depending on the activity of nerve-centres, present in the walls of the stomach,§ and as these are evidently not stimulated by mustard, or the gastric secretion would be increased, we may reasonably infer that the larger nervous circle, before referred to, through which reflex nervous impulses take place between the stomach and brain, are equally unstimulated by mustard. There is, therefore, reason to conclude that the real action of mustard on these nerves is of a depressing kind, and like others of its class, acts by freeing the muscular fibre of the gastric walls from the influence of their restraining nerves, in accordance with the view of "irritation" just stated.

272. *Tickling the fauces.*—In regard to the manner in which vomiting is brought about by titilating the fauces, there seems little reason why so innocent a procedure, should either excite or depress

*Dr. Carpenter's Human Physiology, p. 408. †Action of Medicines, note, p. 105.
‡Drs. Todd and Bowman, Phys. Anat., p. 213. ‖Therapeutics, p. 360. §Dr. L. Brunton, Hand-book for the Physiol. Laboratory, p. 492.

the functional activity of the nerves concerned in vomiting. Still, if we must regard the effect produced, in this instance, as originating in more than a mere ideo-motor impulse, called forth by a strong desire to produce emesis, and a fixed belief that this process will achieve it, we must refer it to a change in the molecular nerve current, which in this case is equivalent to depression.

273. Dr. Anstie distinctly refers to vomiting as an effect of paralysis of the medulla oblongata in narcotism,* and if this is true of one case, or of one series of cases, we have reasonable ground for attributing vomiting otherwise arising to depression rather than to excitation of the nerves concerned in it.

274. *The vomiting of pregnancy.*—Why the gravid uterus, in any stage of gestation, should occasion either stimulation or paralysis, of the gastric nerves, and by either process set up contraction of the muscular walls of the stomach, with its attendant results, is by no means obvious. But that the rapid development going on, not only in the uterine tissue, but in the contents of that organ, during the early part of pregnancy, should require, and attract to itself a much larger than ordinary share of the *vis nervosa* of the body, is not at all surprising. Nor is it to be wondered at, that in consequence of this excessive demand for nerve-force on the part of the uterus, the stomach should suffer a deprivation of the same, with the consequences which follow such deprivation.

275. We see, very commonly, a similar state of things existing between the brain and the stomach. Severe mental effort, by attracting an unusual amount of blood and pabulum to the cranial ganglia, to replenish the corresponding waste, deprives the stomach of its customary supply, causing retarded and impaired digestion. A full meal, on the other hand, as is well known, is a very unfavorable condition for mental labor: nerve-force being pre-engaged in the process of digestion, is, in most persons, unable to afford sufficient additional energy to the brain to carry on a simultaneous expenditure of nerve-force there. If severe mental effort or active muscular exercise be enforced, during these circumstances, digestion suffers proportionably to the diversion of nerve-force in each case.

276. These demands upon nerve-force, however, are at most only of periodical or occasional occurrence; while in the case of the uterus, the progressive development and consequent demand for vital energy is incessant, for months at a time: so that the monopoly and its consequences tend to perpetuate themselves.

In our highly civilized communities, where physical necessities, mental anxieties, social customs, late hours, and other concomitants of life at high pressure, tend to exhaust nerve-force, the condition we are considering is more prevalent and distressing than

*Stim. and Narcot., p. 168.

in ruder states of society, where life is less artificial and more natural.

If to these causes of nerve exhaustion, be added an irregular distribution of nerve-force among the organs, and the large extent to which it is monopolized by the impregnated uterus, we may find a sufficient explanation of the vomiting of pregnancy. Deprived of its normal nervous restraint, the gastric muscle ceases to be adequately controlled: slight additional causes of nervous depression give to its muscular fibres the preponderance over weakened nerve-force, and the result is seen in those irregular, untimely, and excessive spasmodic contractions of the stomach, by which its contents are ejected, with much suffering and inconvenience. This abnormal condition is sometimes continued during the greater portion of the period of gestation, until the uterus, having completed the process of storing up nerve-force in its thickened walls, utilizes it in powerful efforts for extruding its contents.

277. So far as we know, this is an entirely new and original method of accounting for the vomiting of pregnancy. If we avowed any feeling of diffidence in presenting it, we fear our statement would hardly receive the credence it deserves, seeing that we have already ventured to commit ourselves to so much not in the beaten track of present medical opinions. However, we think there is a basis of truth in it, and proceed to add, that this view of the question suggests a modification to some extent, of the method of treating that condition.

278. Among the indications in question, which will naturally suggest themselves to the intelligent reader, are, the withholding of remedies of the purely "sedative" class, at least in sedative doses, which are often prescribed under the assumed necessity of "quieting" irritation of the gastric nerves. If these nerves are already too poorly supplied with nerve-force, from the cause assigned, we should seek, not indeed to starve those of the uterus, but to place those of the stomach in a condition for receiving a fuller supply. Here, as elsewhere, the expenditure should be kept strictly within the income, and an effort made by physical and mental rest and quietude, by good air, recreation and cheerful surroundings, and such other hygienic influences as are available, to secure as large a margin as possible of surplus nerve-force over its consumption in the organism. Our efforts may be aided by gentle frictions over the stomach, and other means having a tendency to direct the attention and concentrate ideo-motor impulses to a greater extent on that organ.

279. It is a circumstance favorable to our theory that many of the remedies which experience has sanctioned, will be found, here as elsewhere, to be in full accord with it. Nux vomica has long had a reputation in this connection. Cod-liver oil, where it can be

borne, and phosphorus, suitably administered, ought to be indicated. Arsenic or quinine will sometimes be valuable, in suitable cases. A reference to the "food action" of these drugs will find a place in a future chapter.

Drugs which aid in the nourishment of nerve-cells or nerve tissue, should be administered separately, rather than combined, and in small doses, which just approximate, but do not produce their ordinary pathogenetic effects. Vinum ipecacuanha deserves special mention for its power in controlling ordinary functional vomiting. It should be given in drop doses, or less for children, in a teaspoonful of water. In the vomiting of pregnancy it will often be of value, and may be alternated with one or other of the more purely neurotic remedies.

Of course, undue acidity should be corrected with mild alkalies; excessive flatulence with proper dietary regimen. Old bread should be preferred to fresh; a moderate quantity of cold water substituted for hot drinks; tea used sparingly; ginger and peppermint slops, never. A fair quantity of good animal food is to be preferred to a diet chiefly of vegetables. Without proper regard to these and other minutiæ, mere drug action, under any theory of the case, cannot be expected to succeed; but in spite of our best efforts our success will sometimes be only partial.

280. We must not omit to notice two methods of treatment, directed to the uterus itself, which are vouched for as having promptly arrested the vomiting of pregnancy. One is, the mechanical dilatation of the os and cervix, by the finger. Two physicians, Dr. Copeman, President of the British Medical Association, and Dr. Thomas, of Swansea, report the favorable results of this procedure.*

The other, and most recent method of treatment, for this condition, is the free application of the solid nitrate of silver to the os and cervix uteri, from which procedure prompt and successful results are reported in the journals.

We do not see anything in either of these modes of operation antagonistic to the theory above suggested. In both cases, the sensory nerves of the os and cervix are more or less irritated; though, for various reasons, these vaginal mucous surfaces are less sensitive to such impressions than the external integument. The impression transmitted by these nerves to their centres, and from thence reflected back to the body of the uterus, is not necessarily of the nature of a stimulus; as we have heretofore shewn in the case of other irritations of nerves. (§ 270.)

To show how completely the term "stimulus" is sometimes improperly used, let us consider what is the effect of a caustic application to the too exuberant granulations of a wound or ulcer. These granulations, vulgarly called "proud flesh," do not indicate a

* Brit. Med. Jour., 1875, pp. 637, 707. Braith. Retros., January, 1876, pp. 208, 210.

weak or lowered vitality of the sore; on the contrary, there is too profuse a supply of bioplasm, or new forming material, undergoing excessive development. What we do by lightly touching the part with caustic, is to check redundant growth; and in doing so we kill many of the bioplasts, and cause the remaining germinal matter to grow more slowly and more normally. This is not stimulation, but repression.*

A similar excess of plastic or formative material, and corresponding cell growth, occurs in the inflammatory process. In chronic pneumonia, the application of blisters, when beneficial, is doubtless to be explained by the reflex influence they exert in contracting the walls of the dilated blood vessels, which, in consequence, convey less blood and pabulum to the focus of cell growth, thus favoring the extinction of the inflammatory process.† We make this statement advisedly, because it has been shewn that the "depletive" or "revulsive" theories of counter-irritation are unsatisfactory or untenable; and that the remaining hypothesis which regards the morbid action within, as "superseded" by the artificial one thus created on the surface, is "really a relic of notions belonging to times which were antecedent to the birth of scientific physiology."‡

In the uterus, a greater, though normal, yet extraordinary, cell growth and development is going on, requiring a proportionate monopoly of nerve-force. Now, if here, by reflex action, through the sensory nerves acting on the vaso-motor and trophic or nutritive nerves, this process were restrained, or modified, so as to proceed less rapidly, and thereby make a less urgent demand upon nerve-force, more of this indispensible product would be available for other organs, and for restraining the untimely contractions of the muscular walls of the stomach, thus exercising a favorable effect on the vomiting in question.

Thus the two modes of procedure referred to above, may be regarded as forms of irritation, of a depressing rather than of a stimulating kind; resulting in a diminished supply of blood and pabulum to the uterus, or in the lessened utilization of these, in the process in which that organ is engaged. This will not appear unreasonable when we remember that not only a retardation, but even an arrest, of cell growth and development, and the death of the fœtus, occurs at times from causes operating directly or reflexly through the nervous system. We may also call to mind in this connection, the reflex effects of irritation of the urethra by catheterization, and the violent rigors and physical depression which sometimes follow.

281. *Infantile vomiting.*—We have only to suggest on this subject, that surely the presence in the infant's stomach, of undigested food, often in curdy lumps, cannot be the occasion of the calling forth of increased nerve-force; and cannot act as a "stimulus" to

*Dr. Beale, Disease Germs, p. 280, &c. †Ibid., pp. 414, 416, &c. ‡Dr. Anstie, Practitioner, March, 1870, p. 156. Braith. Retros., July, 1870, pp. 70-1.

"the nervous circle:" and is much more likely to cause the transmission of a message to the brain, and such an arrangement of the molecules of the nerves concerned, as is equivalent to depression. The contraction of the stomach, which follows, ejecting the offending mass, results from the concurrent release of the inherent contractile power of that viscus.

282. *The intestinal canal.*—We have now a few words to add in reference to the antagonism between nerve-force and muscular fibre in the control of the intestinal tube.

This great canal, like all other muscular tubes in the body, undergoes a marked degree of contraction in its calibre after death, when nerve-force is no longer present. Prof. Valentin has shewn that if a portion of an intestinal tube from a recently killed animal, be filled with water, one extremity tied and a glass tube connected with the other, the water will rise in a few hours to a considerable height in the tube, owing to the contraction of the intestinal walls.* Paralysis of the intestinal nerves, by electricity, also induces contraction of the same intestinal fibres, and thus doubtless aids in expelling their contents, as this agent is known to do in certain cases. In chronic diarrhœa, with undue relaxation and distension of the intestinal walls, it need excite no surprise if faradization should exert a favorable effect in the same manner. Drs. Beard and Rockwell allude to cures of both constipation and diarrhœa by this agent, in the 2nd edition of their valuable work.† In considering the action of belladonna (§ 331), this subject will be found partially discussed; but must here be considered at greater length.

283. The proper peristaltic action of the intestines may be held to depend upon the maintenance of the due balance of power between the antagonizing forces which regulate its calibre. If motor nerve-force be in excess, the tube will be dilated. If vaso-motor nerve-force be also in excess, the glandulæ and follicles will be freely supplied with blood, and as, a consequence, the secretions will be increased, perhaps to such an extent that a diarrhœa may result.

If motor nerve-force be in abeyance, and muscular contractile power paramount, the calibre of this tube will be reduced, and if secretion be at the same time diminished, from vaso-motor paralysis, as is very likely to occur, the condition of the bowels will be one of sluggishness, torpidity and constipation.

The proper way of remedying the latter condition, is evidently, to assist nerve-force by nutritious food, moderate exercise, and, if need be, by food medicines, which augment the functional activity of the nerve-cells and thus contribute to its increased production. When this method is ignored, and constipation is treated by purgatives, which are generally tissue irritants, and act by irritating the

* Dr. Carpenter's Human Physiology, p. 334. † Pages 579, 580.

glandulæ and follicles through which they are extruded from the blood, after having first passed into the circulation,* or in their way down the intestinal tube, the effects on the general condition are merely temporary, and the chief result is, that as the outraged follicles become accustomed to this mode of assault, they treat it with less attention; and, heavier battalions of pills, powders and drastics have to be thereafter brought into requisition, to compel obedience.

Schroder van der Kolk is quoted as an authority for the statement, that "long experience and a great number of *post mortem* examinations have satisfactorily proved that chronic constipation is almost always dependent on contractions in the descending colon.†

284. The use of fruits, brown bread, &c., assists by the mechanical bulk of these, in overcoming the tendency to contraction: and the increased secretions poured into the canal, as the result of the tissue irritation referred to, aid, no doubt, in a similar manner.

Besides this general action, as tissue irritants, which is common to them all, the saline cathartics, while in the blood, exercise a deteriorating effect on that fluid. The constituents of fibrin are diminished, and the tendency of the red corpuscles to aggregate together, is lessened.‡ This is a species of action which must be admitted to depress motor and vaso-motor nerve-force, and through the latter to lessen vascular activity. Hence the reputed advantages of these in acute febrile cases, where a mild antiphlogistic is indicated.‖

Indeed the action of cathartics generally produces a depression of nerve-force, as felt in the languor and weakness they occasion. So far as this affects the bowels, the result is to favor the contraction of their walls: and if these have been previously moderately dilated, an impetus will be given to their expulsive force. The pouring out of copious secretions from the innumerable glandulæ and follicles, tends to distend the bowels; and in proportion to the vigor of the muscular contractions, on one hand, and the bulk of the fœces, mechanically dilating the tube on the other, will be the resulting peristaltic action. To the same cause may be attributed the irritation of the sensitive nerves causing tormina or griping, which is rarely absent during the process in question.

If we substitute for the distending pressure of fœcal matter, a relatively large quantity of flatus, the product of mal-digestion, a nearly similar condition of the antagonists results; the dilating influence of the nerves, aided by the expansive force of the flatus, sometimes occasions great distension, which, however, is usually limited to a particular portion or tract of the tube. This constitutes colic.

*Headland, Action of Medicines, pp. 109, 337, &c. †Dr. Richard Hughes, Pharmacodynamics, p. 421. ‡Dr. Headland, Action of Medicines, p. 212. ‖Ibid.

285. The treatment, which experience has justified, is in accord with the view just enunciated. Warm fomentations externally produce a "sedative" effect, not only on the sensitive nerves which transmit the pain, but on the motor nerves which are promoting the dilatation. Sedatives internally, as opium or morphia, &c., by paralyzing these nerves, produce similiar beneficial effects, in the same manner; and these means may be further aided if necessary by copious injections of warm fluids, to distend the bowels below the dilated portion, partly by their mechanical bulk, and partly by the stimulus they afford to the local nerves of this portion of the tube, and so favor the passing away of the flatus. Sometimes, indeed, one or other of the diffusible stimulants, by increasing dilating nerve-power in the constricted, or less dilated, portion of intestine, above or below the flatus, proves a valuable auxiliary in promoting the object in view.

286. We have only to quote Dr. Carpenter to prove, not only the contractility of the muscular fibres of the intestines, but also that they are in no way dependent on nervous agency for the exercise of that endowment. He says:—"The ordinary peristaltic movements of the intestinal canal are fully accounted for by referring them to the contractility of the muscular portion of its walls, called into action by direct stimulation: and that they are not in any degree dependent upon nervous connection with the cerebro-spinal centres, is clearly shewn by their continuation after the destruction of these." Again, "The intestinal tube, from the stomach to the rectum, is not dependent upon the nervous centres, either for its contractility or for its power of exercising it, but is enabled to expel its contents by its own inherent powers; still we find that here as in other instances, the nervous centres exert a general control over even the organic functions, doubtless for the purpose of harmonizing them with each other, and with the conditions of the organs of animal life."* What we ask the reader to believe, is, that muscular tissue comes under the domination of that general "control" just mentioned; not for the purpose of exciting contraction in its fibres, which, as we have just seen, is unnecessary, but for restraining that contraction, the continuance of which after the destruction of the nerves, is so clearly pointed out.

287. We submit that the natural and legitimate conclusion from all this, is strongly in favor of our views. We have seen that section of the pneumogastrics is followed by contraction of that portion of the œsophagus only, which is thereby deprived of nerve influence; and also that the stomach under similar conditions has remained contracted. It is admitted, apparently accidentally, that section of the gastric nerves may cause vomiting. And yet we do not pretend that either section or paralysis of a motor nerve is usually or neces-

* Physiology, pp. 409, 410.

sarily attended by speedy contraction of the muscle it supplies, especially in the case of voluntary muscles. (§ 82).

The continuance of the contractions of the intestinal walls after the destruction of their nerves, is a circumstance the advocates of the dependence of muscular fibre on a nervous "stimulus" would do well to explain.

288. In regard to the behaviour of the nervous system in its relation to the sphincters, we are fortunate in having simply to quote the authorities to show that our theory has nothing to fear from this quarter. Thus Drs. Todd and Bowman state:—"The action of the sphincters of the anus and bladder seems, at first, peculiar. . . . They are constantly contracted unless the contained matters are forced within them by a superior power. Now, their mass, and therefore their contractility, is superior to that of the wall of the cavity above; consequently their passive contraction endures while that of the parts above is being gradually mastered by the accumulation of fæces or urine. But when these excretions at length excite active contraction in the walls of the cavities containing them, this overcomes the passive contraction of the sphincters and the evacuation occurs. The sphincters have striped fibres and voluntary nerves, by means of which we can, for a time, add active to passive contraction, and thus retard the expulsion; but, as the accumulation proceeds, this power is diminished or lost, and the sphincters yield. The levator and sphincter ani frequently aid the accumulation of the fæces by temporary active contractions, by which the fæces tending to dilate the sphincter are pushed backwards for a while. The rectum is thus preserved empty until the period immediately preceding defecation."

"In paralysis of the lower part of the body from disease or injury of the spine, the *voluntary* power of the sphincters is lost, and the fæces and urine pass involuntarily. *But this is no proof as is commonly imagined, that the ordinary contraction of the sphincter is an active one, performed in obedience to a continuous nervous stimulus.* The difference is, that it can now induce no active contraction through the nerves, to counteract temporarily, and in obedience to the will, *the active contractions of the parts above, which are not under the influence of volition, and are not paralyzed.* Hence, whenever the fæces are driven against it, it gives way, against the patient's will; and—if the sensitive nerves are also paralyzed—without his knowledge."*

Here the independent power of the intestines and bladder is again distinctly stated. "The parts above" the sphincters are not paralyzed; but, on the contrary, their "active contractions" force open the passively contracted sphincter, which retains its inherent contractile power, and exerts it, but is unable to receive any aid from the power of the will acting through the motor nerves, and

* Physiol. Anat., p. 180.

consequently it is overpowered and yields to a pressure against which it has struggled in vain. How curious it is that silent forces should be thus operating within us, for our benefit, of which we are wholly unconscious!

The authors just quoted, further state :—" An examination of the action of the sphincter will show that the anus is kept closed ordinarily *by the passive contraction of the muscle itself.* . . . . Dr. Hall indeed cites two experiments which imply that the action of the sphincter is dependent on the cord. In both, however—one on a horse, the other on a turtle—the observations were made immediately after division of the cord. By the division, the whole organ was thrown into an excited state, both above and below the section, and therefore manifested phenomena similar to those excited by volition. Indeed, *we have seen the sphincter repeatedly contracting, after the division of the cord,* without the application of any new stimulus to it; and the dog continuing to raise and depress his tail as long as the irritation of the cord produced by the section has continued.*

We need not support this part of the argument any further, since it will be seen from the foregoing how fully in accord our general theory is with the action of the sphincter, as presented by the eminent physiologists we have quoted.

289. Do any of our jocular and less thoughtful readers enquire, why, after section of the spinal cord, and the consequent "liberation of the muscles" of the dog's tail, from "the restraining influence of their nerves,"—to quote our own words—and after the subsidence of the pain and excitation of the nerve tissue, consequent on the section, the tail does not continue to wag, from "the inherent contractile power of its muscular tissue," which is now entirely free to assert itself? If our friend will study the anatomical arrangement of the interesting part in question, he will find, that muscles, there as elsewhere, have their antagonizing muscles, and that when one contracts, its opponent must relax; but when all the antagonists are in an equal state of relaxation, passive contraction, or rigidity, any motion of the part they govern is impossible. Our would-be critic will find it necessary to discover some better support for his argument than the useful appendage referred to.

290. As a corroboration of the foregoing views of the activity of the intestinal muscular fibres, when released from the domination of their motor nerves, we append the following, which is communicated to us by a medical gentleman of ripe judgment and rare powers of observation. This gentleman had a favourite dog, who became unaccountably ill, declining food and drink, lay continuously on the bare earth, on his belly, and looked very sad. After sixty hours had elapsed, and seeing that the dog showed some aversion to drink-

* Physiol. Anat., pp. 299, 300.

ing, Dr. W—— began to fear the onset of hydrophobia. A medical friend attempted to administer a purgative bolus, but the dog snapped at him, and as a viscid saliva was running from his mouth, a coal sledge was brought into requisition, and the dog was killed by a blow on the head. While a grave was being dug in the vicinity, they heard a pretty loud sound, and on looking round were surprised to see that a copious black semi-fluid discharge had been expelled from the bowels, having an extremely offensive odor.

How is this curious circumstance to be explained? The advocate of the accepted theory may claim that during life the intensified action of nerve-force so "stimulated" the sphincter of the rectum, as to retain the fæcal mass; and that death, by withdrawing that "stimulus," left the sphincter paralyzed and relaxed, and hence the post mortem discharge.

But to argue thus is to ignore the facts of physiology, which shew that the passive contraction of the sphincter is depending, not on nervous agency, but on the inherent power of the muscle itself. Voluntary effort might, indeed, temporarily, but not continuously, assist in maintaining this passive contraction and closure of the sphincter, but this would be the case much less in the dog than in man, because animals are accustomed to defecate whenever the presence of fæces calls for this act.

Is it not much more reasonable, and in accordance with physiological consistency, to assume that the retention of this mass was owing to the want of contractile power in "the parts above," which, during life, were overpowered by an antagonizing dilating force, and that when death put an end to this restraining power of the nerves, and left the muscular contractile power of the intestinal walls free to act, the necessary contraction took place, expelling the accumulated mass?

The explanation we have supposed to be offered above, namely, an increased stimulus from nerve agency, compelling the sphincter to contract,—necessitates an unusual development of nerve-force on this occasion. But, we ask, were the physical conditions favorable for such an exertion of nerve-force, in excess of its ordinary activity? Sickness, fasting, solitude, and sadness—which the facial expression even of a dog can plainly indicate—were not favorable conditions for the development of such a marked increase of nervous energy. Indeed the very existence of such an exudation, indicated a depraved condition of the system, and its elimination, must already have severely taxed the vital forces. The situation then is not at all favorable, nay, it is inconsistent with increased nerve-force, which is itself a product of cell-life, depends on just such conditions as favor normal cell activity generally, and is not an entity, existing *sui generis*.

But it may be said, on the theory we advocate, there must also have been a great preponderance of nerve-force, to restrain the con-

tractility, and consequently the expulsive force of the intestinal walls. Not so, because the mechanical bulk of this fæcal mass, would, of itself, offer an obstacle to intestinal contraction, and this passive force, in conjunction with ordinary nerve-force, would suffice to prevent contraction of the muscular walls. By removing one of the allies—nerve-force—the balance of power is reversed, and muscle triumphs.

291. In now bringing this part of our subject to a close, we ask the reader to bear in mind that the quotations adduced in this essay, in favor of our theory, are drawn from writers whose facts were compiled under the dominant idea of a hypothesis they were engaged in establishing; and from experiments, in recording which, they would naturally and innocently dwell most forcibly on those observations favorable to that hypothesis, to the perhaps unconscious omission of circumstances favorable to a different but unthought of interpretation. To expect a full endorsation of the views here presented, in such a quarter, would be impossible.

It will, of course, remain for the reader to judge, candidly and fairly, of the merits of this theory, in view of such authoritative admissions as we have been able to gather, and from such general considerations as have served to show its adaptation to the phenomena of disease and remedial agents. We claim that there is a consistence in the assumed modes of action, both on the part of nerve-force and drugs, which contrasts very favorably with the accepted physiological theory of the action of both; the latter theory, as we have already shewn, necessitating the alternate and even simultaneous presence of stimulation and paralysis in the same nerve, and by the same drug, in order to meet the exigencies of the theory.

CHAPTER X.

HINTS ON THE ACTION OF MEDICINES IN ACCORDANCE WITH THE THEORY HERE SUGGESTED.

292. *Sixth general principle.*—Certain drugs, by modifying the activity of the vaso-motor nerves, (increasing their power by nutritive changes in the cells which generate nerve-force, or paralyzing the nerves themselves, and so arresting their functional activity,) cause an increase or diminution of the calibre of the blood vessels; and so exert an important influence, not only over the nutrition and temperature of parts, but in controlling congestion and inflammatory processes, and so restoring normal circulatory activity.

293. The principles advanced in the foregoing pages, although of much interest and importance to both physiology and therapeutics, would have their practical value materially enhanced, if they served to some extent to interpret the action of medicines and to guide to their proper application in disease.

294. How drugs act, in the various curative processes, is a problem surrounded by the gravest difficulties, and one which, at present, it is impossible to solve. But in the case of many, which act through the agency of the nerves, the theory we have ventured to suggest affords a rational guide to their uses in morbid states; and on this basis, aided by recorded facts, we propose to offer a few hints on this very difficult subject.

In a general way, drugs expend their action:—

(a.) In modifying the quality of the blood.

(b.) In modifying the nutritive and functional activity of the tissues and organs, directly.

(c.) In modifying the nutritive and functional activity of the tissues and organs, *through the agency of the vaso-motor nerves*, as regulators of the blood supply and pabulum which reach them.

Of the first two of these modes of action, we have nothing sufficiently new or important to add to what is already taught, to justify a special reference to them here. They will be noticed incidentally, however, inasmuch as several drugs exert a direct influence over the blood and tissues, in addition to the indirect influence which they exert over the latter through the nervous system.

295. We have already had occasion, in the previous pages, to refer to the physiological law, "that the functional activity of an organ is directly proportionate to the supply of blood to the organ."*

* Dr. C. B. Radcliffe, Lectures on Epilepsy, &c., p. 238.

Guided by this leading principle, we may assume as a rule, that those drugs which lessen or abolish the functional activity of an organ,—as a gland,—do so by diminishing its blood supply, and with this the pabulum on which its functional activity is fed: while the very reverse condition applies in the case of drugs which manifestly increase the functional activity of an organ. Here, blood supply is augmented. This necessitates a previous dilatation of the arterial walls, which effect, in turn, depends on vaso-motor,—dilating—activity: hence the drug of this class is one which improves or reinforces the development of nerve-power, of which the increased vascularity and augmented secretion are the consequences.

296. We have, then, before us, the distinctive effects of two classes of drugs, both acting through the nervous system.

(a.) Drugs, which, by *paralyzing* the vaso-motor nerves induce vascular *contraction* and its consequences, diminished blood supply and lessened, or arrested, functional activity, secretion, etc.

(b.) Drugs, which, by *reinforcing* the vaso-motor nerves induce vascular *dilatation*, with increased afflux of blood, and as a consequence, augmented functional activity.

297. We have to notice in this connection—and will refer to the fact hereafter—that increased secretion is not always, or necessarily, dependent upon *dilatation of the blood vessels* leading to the gland or tissue displaying this increased activity: for certain paralyzing drugs, as opium and calabar bean, in poisonous doses, occasion profuse perspiration and an excess of other secretions, although they are at the time paralyzing the vaso-motor nerves, with the effect of diminishing the calibre of the blood vessels, and so lessening general vascular activity. Indeed, certain secretions,—including perspiration—continue to be formed after the general death of the body, and under these circumstances, they cannot be attributed to nervous influence, or to an increased supply of blood from dilated arteries. The explanation of these facts, in apparent contradiction to the "rule" mentioned above, and to the formula "*b*," is not far to seek. The vaso-motor nerves control the calibre of the arteries, but so far as yet known, *not that of the capillaries*, which have an independent "power" of their own over their contents.* When the larger arteries are diminished in calibre, the blood which they contain is necessarily forced towards, and into, the veins.

As the capillaries are the channels through which this afflux takes place, their temporary distention is a matter of course: hence the capillary circulation generally, including that of the glands within the body, and of the skin, may be rendered more active for a time. Thus, increased blood supply may be present in the tissue or gland displaying temporarily augmented functional activity, although there is no dilatation, but even the reverse, of the arterial tubes leading in that direction.

*Dr. Carpenter's Physiology, p. 494.

298. In other cases, certain drugs cause increased secretion by *direct irritation of the tissues* concerned, without active determination of blood to the part. Here, according to Prof. Kuss, the secreting cells imbibe the materials on which they feed from the surrounding tissues.*

From these observations it will be seen that the first of these apparent exceptions to the general rule stated above, based on Dr. Radcliffe's physiological law, is not really so exceptional as it might at first appear, and practically is not exceptional at all: and as for the other class of cases,—where secretion results from tissue irritation— we have not claimed that all drugs are neurotics, or that they display their effects solely through the medium of the nervous system; though this is the rule with many. Thus, aconite, while it is essentially a paralyzer of nervous tissue, has acrid properties, which are shewn in its effects on the mouth and the adjacent sub-mucous glands: and the anodyne morphia, in its passage out of the system, through the skin, sets up irritation, itching, and even efflorescence.

These diverse effects of the same drug, are embarassing to any system of classification; but as we have set ourselves chiefly to elucidate the effects of drugs operating *through the nervous system*, we shall give this feature prominence and regard direct tissue irritation, when it occurs, in otherwise neurotics, as incidental and secondary.

299. In considering drugs from this point of view, it is important to bear in mind what has been already advanced as to the effects of impressions made upon different parts of the nervous circuit. Thus, an exciting or depressing influence, affecting a sensitive nerve, is carried to the nervous centre or ganglion with which that afferent nerve is connected, and is reflected thence upon the corresponding motor nerve. This is one mode in which the results of exciting or depressing influences may be attained. A second mode is by impressions made directly upon the nervous centres, or ganglia, themselves; and a third, where the exciting or paralyzing influence impresses the motor nerves directly.

Drugs may impress each of these portions of the nervous circuit, to the exclusion of other portions; and hence, while their general effect may be that of paralyzers or excitors of vaso-motor activity, their special action may be different, owing to the portion of the nervous tissue which they primarily impress. Examples of this will be found as we advance.

300. Before proceeding to a brief notice of several drugs belonging to each of these classes, we desire to offer a few further remarks in reference to drug action in general.

And first, we have to remind the reader, of the marked difference in effect between small and large doses of the same drug. In

*Lectures on Physiol., Duval, Amory, p. 219.

numerous instances, even our most potent poisons exhibit, in minute doses, effects on the organism, which would appear to entitle them to the designation, in a certain sense, of foods. Thus, common salt, so familiar and indispensible to us as a condiment, is a useful and safe emetic in medium doses, while in extremely large doses it is an irritant poison, and has caused death in several cases.* The now well authenticated use of arsenic by the Styrian people, for nutritive purposes, and the value of strychnia, in small doses, in coldness of the extremities, from deficient dilating nerve power, are examples in point, which might easily be multiplied. "Indeed, it is hardly too much to say that we cannot state with certainty of any food, that it may not also be a medicine and a poison; nor of any poison that it may not also be a medicine and a food, under some circumstances."†

301. Some of the effects we are now considering are doubtless produced upon the tissues, either directly, or through the medium of the trophic or other nerves, which preside over nutrition, or by an influence exerted upon nerve-force acting on the vaso-motor nerves, where the results are attended by increased vascular activity. We have before remarked, that nerve-force is not an entity nor an individuality, to be arbitrarily invoked or restrained; but depends for its production upon a healthy nutrition of the cells in which it originates.‡ Those agents, then, which cause its development, must, in some way, contribute to normal nutritive changes, and so to some extent, partake of the character of a food.

302. But we have further to notice, besides this food action of certain drugs, in small doses, the fact, that the minimum or moderate dose of some drugs produces physiological effects of a well marked kind, apparently a degree beyond what can be attributed to a food action; and which, besides, is of an opposite kind to the action of large or full doses of the same drug.

Thus, chloroform is a stimulant in the first stage of its operation, but subsequently a profound paralyzer. Chloral hydrate often causes temporary cerebral excitement and a remarkable flushing, before its sedative and narcotic effects are displayed. Opium in small doses, allays bronchial irritability, and is then an indirect expectorant, but in large doses it renders respiration difficult and expectoration impossible. (Headland.)

We shall shortly see, that the condition of the system, has, at times, an important influence in determining the effects of certain drugs, of which digitalis furnishes a good example: but this mode of explanation does not suffice for all. As we can neither alter the fact in question, nor ignore it, we must only allow it its full weight in the conclusions to be arrived at.

*Dr. Anstie, Stim. and Narcot., p. 29. †Ibid, p. 31. ‡Dr. Carpenter's Human Physiol., p. 132.

303. In what is to follow, we do not undertake to deal exhaustively with the several drugs to be mentioned, as to do so would fill a volume in itself. What is intended, is to show the adaptation of the theory suggested in these pages to the mode of action of leading remedies, and perhaps to blend with this a few practical hints, which may enhance the usefulness of this work to the student.

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DRUGS WHICH PARALYZE VASO-MOTOR NERVE ACTION, AND SO TEND TO INDUCE ARTERIAL CONTRACTION.

304. *ACONITE.*—This may be taken as a typical drug of the sedative class. No one who reads the symptoms of poisoning by aconite, can doubt for a moment that it is a profound paralyzer of nerve-force, both sensitive and motor: while at the same time it leaves the cerebrum and the faculties which act through it, usually uninfluenced, almost until death closes the scene. How, amid such general paralysis as aconite induces, it could ever have been regarded as an excitor* of any part of the nervous system is surprising.

And yet, though it is not generally taught that aconite is an excitor, the accepted vaso-motor theory requires that it be so regarded; for, according to that theory:—

Vaso-motor excitation induces arterial contraction.

Vaso-motor paralysis permits arterial dilatation.†

Arterial contraction is a prominent feature of aconite poisoning, as seen in the general coldness, paleness and faintness; the failing pulse, in spite of the tumultuous action of the heart, the blue lips, livid face, and other signs of collapse, all betoken obstructed circulation, owing to diminished calibre of the vessels, through which even the urgent throbbings of the heart can no longer force the blood.

Sensory and motor power, too, are extinguished; and yet amid this scene of rapid and fatal paralysis, we are taught to look for excitation of the nerves of the blood vessels, (on the theory mentioned,) as the proximate cause on which arterial contraction depends.

Substitute for this impracticable theory the one we have ventured to suggest:—

Normal state.—The inherent contractile power of the arterial coats, opposed by the dilating influence of the vaso-motor nerves, and these antagonizing forces so duly balanced as to maintain healthy circulatory activity.

Abnormal state, (from a narcotic or paralyzing drug).—The vaso-motor nerves paralyzed; their dilating power weakened or abolished;

*Achscharumow, Dr. Ringer's Therapeutics, p. 396. Dr. Meryon, Func. Symp. Syst. of Nerves, p. 52. Dr. Richard Hughes, Pharmacodynamics, pp. 39, 40. †See references, § 194.

giving an undue preponderance to the contracting power of the arterial walls, inducing arterial contraction, with the effect of paleness, coldness, collapse, etc. Aconite an example.

Abnormal state, (from a stimulant or exciting drug).—The vaso-motor nerves excited; their dilating power increased, so as to over balance the contractile power of the muscular walls of the arteries, resulting in arterial dilatation, as in flushing, hyperæmia, etc. Nitrite of amyl and the first stage of alcohol, examples.

This schema accords with the phenomena of aconite poisoning. It recognizes the general paralysis which is predominant throughout. It accounts for the power of aconite in congestive and inflammatory states, and it does this in a simple and natural manner.

305. Here, the vaso-motor (dilating) nerves are paralyzed, and have their functional activity suspended. As a consequence, the inherent contractile power of the muscular fibre of the coats of the arteries comes into unrestrained action; reduces the calibre of the vessels, and so retards, or ends, the undue afflux of blood, with its injurious or ruinous consequences.

306. Aconite is chiefly of use in the early stage of vascular excitement, and before secondary changes, or effusion of bioplasm, has taken place. "It has no influence on the blood itself, and will fail to control such fevers as depend upon a poisoned state of that fluid. Its use in gastric, typhoid, typhus and yellow fevers, is mere waste of precious time, and even in scarlatina, variola and measles, it will not lower the circulation until the eruption comes out."* Still, it is often of material use in the latter series of cases; but where the fever is very intense, the constitution vigorous and the pulse full or bounding, it has a powerful rival in veratrum viride, which may often be substituted for it with advantage. In the hot stage of intermittent fever, aconite is much inferior to gelseminum.

It has been recommended for rheumatic and neuralgic affections, but apart from its paralyzing and benumbing effects on sensitive nerves, its utility here will be found limited to those cases attended with, or dependent on, a congested or hyperæmic condition of the neurilemma or nerve sheath; for which this drug is appropriate, as in similar congestive states elsewhere.

307. Cases of aconite poisoning are not unfrequently attended by tremors, spasms and convulsions. In the antecedent pages we have shewn reasons for attributing these effects to a withdrawal of nerve influence from the muscles, rather than to an "excitation of the nervous centres." The general paralysis of the motor nervous system induced by aconite, accords with this view.

308. There is much confusion in regard to the various preparations of this drug; there being four different tinctures in ordinary use, one of the leaves and three of the root. From one to four

*Dr. Richard Hughes, Pharmacodynamics, p. 41.

minims of the B. P. tincture may be given every half hour, hour, two hours, or at longer intervals, according to the activity of the circulation and the urgency of the symptoms. Fleming's tincture is about six times stronger, and should be prescribed accordingly in proportionate doses.

309. *VERATRUM VIRIDE.*—This drug has been found invaluable in sthenic inflammatory fever, of any tissue or organ, with full bounding pulse and great vascular activity. One to four drops of the fluid extract, in a teaspoonful of cold water, for an adult, every half hour, hour or two hours, according to the severity of the symptoms, to be diminished in quantity or frequency as these abate, will succeed even better than aconite in subduing arterial excitement, lowering temperature, and modifying the inflammatory or acute febrile state. In presence of such results blood-letting is not to be thought of.

310. Like other paralyzers of nerve tissue, its excessive use will induce prostration and even alarming symptoms; and like others of this class, also, it is not applicable to adynamic fevers, of a low type, where both nerve and muscular force are already enfeebled. Here, the true remedies are cleanliness, fresh air, and nutrient foods and medicines of a corresponding class.

311. As usual, in accordance with current therapeutics, Dr. Ringer, and others, attribute the muscular spasms and convulsions produced by poisonous doses of veratrum and its alkaloids, to "heightened reflex function of the spinal cord," at the very time, too, when, on his own shewing, the cord and motor nerves are being paralyzed![*] The reader can see how much more reasonable and consistent is the view here suggested. Its mode of action is undoubtedly like that of aconite, *i. e.*, by paralyzing the vaso-motor nerves, the contractile fibres of the arterial tubes are enabled to diminish the calibre of these vessels, thus relieving hyperæmia, congestion, etc., and favoring a return to normal circulatory activity. If the dose be too large, or too often repeated, prostration, vomiting, etc., will result: while in extreme cases a further extension of this motor paralysis, by setting free the contractile power of muscular tissue will usher in spasms or convulsions. Here, the action attributed to the drug is uniform, consistent and rational; and applies to a greater or less degree to the action of other drugs of this class, which have yet to be considered. A stimulant is the best antidote to the state of depression referred to, which should never be produced.

Besides the special usefulness of this drug in sthenic inflammatory fever, it has been highly recommended for internal use in acute inflammatory rheumatism, and externally as a lotion in erysipelas. The dose has been already mentioned.

[*] Therapeutics, p, 377-8.

312. *GELSEMINUM.*—This is another paralyzer of motor nerves generally, of which effect the vaso-motor nerves receive a due share. Owing to some peculiarity of its quality this drug is especially adapted for the febrile stage of intermittents. It must also impress the sensitive nerves, for it is occasionally highly useful in neuralgia, sciatica, etc. Of its utility in relieving after-pains, the writer can bear witness.

Administered to excess, it paralyzes the optic nerve, so as to induce dim-sightedness, or even temporary blindness.

313. The fluid extract of gelseminum in doses of from one to four drops, in a teaspoonful of water, repeated every couple of hours, or as the exigency of the case may require, will be found a very useful remedy, not only in the conditions mentioned, but in simple ephemeral fever, and in moderate fevers generally, including those of the exanthemata.

314. It very promptly relieves those states of "rigor" often witnessed after parturition, following extraction of a tooth, or other slight operation, where a general tremor, with chattering of the teeth, etc., occurs, but without a real chill, or sensation of cold. In sleeplessness from mental worry, etc., it has induced sleep. It is prescribed with confidence by some persons, in spermatorrhœa. In all these cases, its action is that of a uniform paralyzer of vaso-motor activity, diminishing hyperæmia, like other sedative drugs, in the manner already indicated.

315. Dr. Ringer, as usual, furnishes us with a refreshing illustration of the absurdity of the accepted theory of vaso-motor innervation; or rather of the shifts to which its adherents are driven, in accounting by it for the phenomena of disease. Of this drug he writes:—"It is interesting to observe, that large doses of the alkaloid, at first *paralyze*, and then *excite* tetanus, which in a short time gives way to *paralysis*."* What would be thought of a system of Natural Philosophy, which required us to believe that cold, at first freezes water, then melts it, and soon after freezes it again! When such teachings are orthodox (?) surely a little medical heresy is commendable, rather than otherwise. But the error here is on the other side; and the theory of these pages is in strict accord with sound physiological science.

316. *OPIUM.*—The uses of this great sedative are well known. The difference in effect between small and large doses—a difference which might lead to the supposition that they belonged to different drugs,—is very well marked. The former may, perhaps, be considered equivalent to a species of food action, as supplying a certain want in the system, and thereby reinforcing nerve-power, in those conditions in which such doses are indicated.

317. It is with the sedative or narcotic dose that we have here to deal. The manner in which this action of the drug relieves the after-pains

*Therapeutics, p. 454.

of parturition, and yet promotes uterine contraction, has been pointed out. (§ 186). The same rule holds good in the body generally. Opium and morphia are among the remedies which paralyze nerve-force, producing thereby contraction of the muscular fibre of the arterial tubes, reducing their calibre, diminishing hyperæmia, &c., and accordingly, are among our most valuable remedies for congestive and inflammatory states.*

That they are narcotics, and so paralyze nerve-force, is undisputed. Their mode of action on the blood vessels accords well with our theory. They also illustrate the general law referred to in the earlier part of this chapter, which asserts that remedies which are found to lessen vascular activity, diminish secretion, as a consequence, and the reverse.

318. Opium and morphia diminish arterial blood supply and arrest the secretions everywhere. Hence their general use in the cure of indolent ulcers whose unhealthy state is maintained by passive congestion ; in diarrhœa and other morbid fluxes ; and hence, too, their injurious effects in bronchial disease, where the air cells are loaded with mucous or bioplasm, which it is desirable should be expectorated ; which effect, in larger than food or nutritive doses, these drugs tend rather to check than to facilitate, by paralyzing the bronchial nerves and so permitting a tightening of the bronchial tubes owing to the now no longer restrained contractile power of their muscular fibres. On the contrary, in phthisis, these very effects are sometimes an advantage, when bronchial relaxation and its accompaniments are excessive.

319. It is unnecessary to refer at length to the uses of opium. Whenever pain is to be relieved, opium or morphia, by the mouth, or the latter hypodermically, has no successful rival. Here it acts as a paralyzer of the sensitive nerves, just as in reducing the calibre of the bloodvessels it acts by equally paralyzing the vaso-motor nerves : and in its extreme effects it causes convulsions of the voluntary muscles by an extension of the same mode of action.

320. The relief of spasmodic states sometimes afforded by opium, or morphia, is apparently in antagonism to the theory here suggested, since we have held that spasms and irregular muscular contractions are caused by withdrawal or paralysis of nerve-force, by such drugs as these and other narcotics. But the benefit derived in these cases may be accounted for as follows :—1st. Opium by paralyzing the sensory nerves, stultifies the sensation of pain, till the cause shall have ceased, or otherwise have been removed—as in colic—where a stimulant like chloric ether is often more effectual. 2nd. In spasmodic states of voluntary muscles, if opium proves curative, it must be in such conditions of the organism, and in such doses, as to excite and invigorate, rather than depress or paralyze

*Dr. Wilks, Braith. Retros., July, 1869, p. 35. British American Journal, Montreal 1860, p. 179.

the already enfeebled nervous centres ; just as we have before quoted Dr. Anstie to prove that the stimulant dose of chloroform cures or mitigates convulsions, which the narcotism of chloroform is prone to induce. The effect of opium in these cases, then, is akin to what we have called its food action,* rather than to its true physiological effect of sedation or narcotism. This view of the case is strengthened by Dr. Ringer's statement, that the effect of opium as an anti-spasmodic is much enhanced when combined with a stimulant, as alcohol, æther or chloroform.†

321. The same explanation will apply to the reported beneficial effects of hypodermic injections of one-fourth to one-eighth of a grain of morphia in cholera, (by Dr. T. J. Gallagher, of Pittsburg, and others). Here, owing to the condition of the bodily functions it is probable only a part of these doses really comes into use ; that portion may suffice to re-inforce nerve-power, and so favor dilatation of the blood vessels, with a return to circulatory activity and restoration from collapse. Too large a dose, producing "sedative" effects, would certainly prove dangerous under circumstances where nervous prostration is already carried to an extreme.

Having thus shewn that the action of this drug is consistent with the theory here suggested, and having hinted at its general uses in disease, we deem further reference to it unnecessary.

322. *APOMORPHIA.*—This is a hydrochlorate of morphia, and is a product occurring in the retrograde metamorphosis of morphia. It is a snow-white, or grey, amorphous powder. In solution, it is prone to acquire a greenish tinge and in time becomes black ; changes which impair or destroy its efficacy. Its solution in syrup appears to be most stable. It differs from morphia in its chemical reaction and has apparently but feeble hypnotic powers.

323. The chief quality of apomorphia is its rapid production of emesis, without gastric irritation, and without the prolonged sickness attending ordinary emetics. To these advantages are to be added the smallness of the dose required, which enables it to be used hypodermically in certain cases of poisoning, or where swallowing is difficult or impossible, or is resisted, as in the case of children. It has been used for the extruding of foreign bodies from the œsophagus, along with, or rather in advance of, the contents of the stomach.

324. The dose for an adult is from one-tenth to one-twentieth of a grain, and for a child one-fortieth of a grain hypodermically. If swallowed, one-fourth of a grain for an adult, and proportionately to this for a child. Larger doses have been recommended, for example, one-sixth of a grain hypodermically and one-half grain by the mouth, as an average dose for an adult man.‡

* Dr. Wilks, Braith. Retros., July, 1869, p. 36. † Therapeutics, p. 490. ‡ Dr. Walter G. Smith, Dublin Journal of Medical Science ; Braith. Retros., July, 1875, p. 219.

325. Apomorphia is stated by Dr. Samuel J. Gee, of St. Bartholomew's Hospital, to be a powerful depressant and "contra-stimulant." It produces vomiting very promptly, without any gastric irritation, evidently through its action on the cranial centres, acting, as the same writer states, "like a blow on the head, &c." It paralyzes the motor-nerves, producing effects "as if muscular power were gone:" but "the vascular system does not appear to be depressed to an equal extent." It has the drawback of being extremely costly, which may, hower, be obviated in time.

It is the most prompt, certain, and easily administered emetic known, and if further experience guarantee its safety, in proper doses, it will prove a most valuable addition to the materia medica.

Its absorption through the skin of those engaged in manipulating it, causes lassitude, weakness, headache, constant nausea, and sudden vomiting. Apomorphia may be produced from codeia. An intermediate product between the two is chlorocodide, the effects of which are similar to those of codeia, and are salivation, dilatation of the pupil and extreme restlessness; and in fatal doses, *mixed paralysis and spasms*, both tonic and clonic, consciousness remaining unaffected.* The effects of apomorphia, from what is stated of its medicinal use above, and, judging from its origin, must be similar.

It will be seen how fully the action of this drug bears out what we have advanced in a previous chapter, (§ 268), that vomiting is the result of a paralyzing, and not of a stimulating action on the nerves concerned in that process: since apomorphia is admitted to be a powerful depressant, or paralyzer, and at the same time to produce vomiting with remarkable promptitude, in one case within eighty seconds after its hypodermic administration.

326. *BELLADONNA.*—Applying the rule laid down in the earlier part of this chapter, as to the relation between vascular supply and secretive activity, we find, that as belladonna arrests the secretions generally, including that of the mammary, perspiratory and salivary glands,† it must be considered a drug which diminishes the calibre of the blood-vessels.

327. On the other hand, this drug produces a remarkable efflorescence of the skin, not unfrequently attended by evidence of local hyperæmia. We do not include its special effects upon the brain in this category, such as giddiness, intoxication, intolerance of light and sound, cheerful delirium, merry craziness, amaurosis, illusions of vision, &c., because these are all evidences of paralysis rather than of excitation of the cerebrum;‡ as the loss of motor power, difficulty of swallowing, twitching, jactitation, convulsions and coma, are also indications of a similar state of the motor nerves.‖

* Dr. Samuel J. Gee, of St. Bartholomew's Hospital, Braith. Retros., January, 1870, p. 226. †Dr. Ringer, Therapeutics, p. 458. ‡Dr. Anstie, Stim. and Narcot., p. 181. ‖Dr. Ringer, ib., p. 462.

Acrid effects were attributed to this drug by Dr. Christison, owing to the dryness it produces in the mouth and throat; but these effects are attributable rather to the arrest of the secretions of the sub-maxillary and other glands.*

328. As for the signs of hyperæmia referred to, they are not inconsistent with paralysis of the vaso-motor nerves and the consequent diminution in calibre of the arterial system: for it is over the arteries, and not over the capillaries that the vaso-motor nerves exercise control. When the calibre of the larger arteries is first reduced, blood is necessarily forced out of them: and it needs excite no surprise if this should occur under circumstances to occasion a temporary excess of vascularity in the terminal or superficial capillaries. It is asserted by some authorities, that the influence of belladonna exerts itself primarily, or chiefly, on the central portion of the arterial system, while aconite, on the contrary, displays its chief power over the vascular system at the periphery, that is over the smaller arterial ramifications which terminate in the capillaries. If these should contract in advance of the larger arteries, retardation of the flow of blood to the capillaries would be among the earliest effects of aconite; and this circumstance would account for the great value of this drug in congestive and inflammatory states, as compared with belladonna.

329. Dr. Brown-Sequard compares the effects of belladonna on the blood vessels to that of ergot. He has seen the vessels of the pia mater of dogs contract after large doses of both these drugs.† The effects of atropia are similar to those of belladonna, only more intense.

330. We have seen in the foregoing pages how well our theory accounts for the production of diminished vascular action, by agents which paralyze the vaso-motor nerves; and how as a consequence of this reduced calibre of the vessels and diminished blood supply, glandular and other secretions are diminished or arrested, and how even the action of the heart may be presumed to be modified through the same agency. The cerebral phenomena, just recounted, are equally consistent with this view of the action of belladonna: and with an anæmic state of the brain; for Dr. Todd, in "his admirable Lectures on Delirium and Coma, has fully established that the anæmic state is highly favorable to the production of both delirium and coma."‡

331. How shall we account for the successful treatment of constipation by belladonna, as recommended by Trousseau, and confirmed by others?

In order to reply to this interesting enquiry, let us first see what is the cause of constipation. Is it a want of sufficient peristaltic contractile action to urge forward the contents of the intestinal tube? If so, what tissue is at fault? Not the nerves supplied to

*Dr. Ringer, ib., p. 458. †Dr. Ringer, Therapeutics, p. 464. ‡Dr. Anstie, Stim. and Narcot, p. 131.

the intestinal walls, for Dr. Carpenter assures us that, "the ordinary peristaltic movements of the intestinal canal are fully accounted for by referring them to the contractility of the muscular portion of its walls." And again, "the intestinal tube, from the stomach to the rectum, is not dependent upon the nervous centres, either for its contractility or for its power of exercising it; but is enabled to propel its contents *by its own inherent powers.*"*

The nerves supplied to the intestines are those of the sympathetic; but "the motor influence does not originate in the sympathetic ganglia, but is derived from the spinal cord."†

Now, as these spinal motor nerves, passing through the sympathetic ganglia to the intestines, do not incite contraction of the muscular fibres of these, since the intestines possess this power independently of the nerves, it is pertinent to ask what function do these nerves perform? As motor nerves they do not transmit afferent or sensitive impressions, and, besides, sensitive fibres are present for that purpose.

In accordance with the theory here suggested, we ask, is not the function of these motor nerves to restrain the contractile tendency of the muscular fibres of the intestinal tube, just as the vaso-motor nerves do for the arteries, and so to keep that great duct dilated, and when acting in excess, to render it sluggish and inactive, by lessening its contractile and propulsive power over its contents?

Paralysis of these dilating nerves by belladonna or by electricity, and other agents, is thus seen to favor contraction of the intestinal muscular walls; reducing their calibre and urging forward their contents by that peristaltic or vermicular wavy motion, for which unstriated muscular fibre is noted. (See § 282, &c.)

332. If this explanation were true, it may be asked, why do not other paralyzers of motor nerves, as aconite or ergot, produce similar effects on the intestinal tube? Some of these motor paralyzers do so; and of those which do not, it may be said that they doubtless select other portions of the nervous tract on which to display their powers; of which selective affinity we have many examples. Thus, some narcotics paralyze the sensory, some the motor nerves, while others assail the nervous centres. Tartar emetic injected into the veins produces pneumonia, croton oil applied to an abraded surface purges.‡ Dr. Anstie says mercury has a selective affinity for the fifth pair;‖ and other similar examples might be multiplied.

333. Of course the process here mentioned is not the only way in which intestinal activity may be brought about. Increased functional activity of the numerous glands and follicles which pour their secretions into every part of this long tube induce accelerated progression of its contents. Many of the class of medicines known as purgatives effect this result, by promoting these secretions. But this

*Physiology, p. 409. †Ibid. ‡Dr. Headland, Action of Medicines, pp. 298–9. ‖London Lancet, Nov., 1872, on Lead and Mercury poisoning.

is not the mode of action of belladonna, which, as we have seen, arrests secretion generally, throughout the body.

334. It is no slight advantage to a theory which professes to interpret the action of drugs, that it does so by attributing to them an uniform and consistent action, and does not require alternate or even simultaneous excitation and paralysis of nervous tissue by the same dose to account for the phenomena. Contrast the results of the theory here suggested in this respect with such announcements as the following:—"Belladonna *paralyzes* the peripheral branches of the vagus, and *at the same time stimulates* the nervous centres of respiration;"* these centres being the very root or origin of the vagi themselves. Dr. J. Harley attributes to this drug similarly antagonistic action.† In rebuttal of these views we have Dr. Anstie's authority that "the process of narcotism is an *uniform* one, and tends entirely in the direction of nervous death," and that the idea of excitation of one portion of the nervous system going on simultaneously with depression of another portion, "is inconsistent with what any unprejudiced experimenter must observe."‡

335. Of the action of belladonna on the iris enough has been suggested in the section in which the adaptation of our theory to the pupillary changes has been discussed.

336. The therapeutic uses of belladonna depend on the general action heretofore attributed to it. The extract, softened by warm water or glycerine, and freely applied to the mammary glands in threatened mastitis will materially aid in dispersing the engorgement of the vessels on which that state depends. The officinal liniment, locally applied, is said by Dr. Ringer to check excessive perspiration; and in painful conditions of the 5th pair, the same application, or moderate doses of the drug internally, will often prove beneficial. The constrictive power of belladonna over the calibre of blood-vessels is sometimes advantageously employed in aborting boils and other congestive states, as of the os uteri. Dr. Anstie regards this drug as especially adapted for painful states of the pelvic viscera. In irritable bladder, attended with too rapid exfoliation of epithelium, simulating the presence of calculus; and in nocturnal eneuresis from irritation of this viscus, belladonna or atropine, 1-60th to 1-80th of a grain, once or twice a day, frequently relieves.‖ As belladonna is, in great part, eliminated from the blood with the urinary secretion, its effects on the parts concerned in this function may be partly accounted for in this way.

Belladonna has its admirers in the treatment of whooping cough, asthma, delirium of low fever, epilepsy, mania, erysipelas, &c.

337. A great deal has been written in reference to the special influence of belladonna in scarlet fever. Dr. Richard Hughes, a leading homœopathist, and consequently an authority on that side of the

* Dr. S. Ringer, Therapeutics, p. 477. †Ibid, p. 465, &c. ‡Stim. and Narcot. p. 408. ‖Braith. Retros., July, 1869, p. 100.

controversy, states that in the "miliary" variety of scarlatina belladonna is useless. In the ordinary form of the disease it does not shorten its duration; does not diminish the fever; does not influence the sequelæ of scarlatina due to renal affection; and is confessedly unable to cope with the more malignant forms of the disease. Dr. Hughes administers it "somewhat as a matter of faith, resting on analogy," we are led to suppose between the rash produced by belladonna and that of the disease.* This is rather a poor record by a friendly hand, in reference to a drug about which so much has been written, in connection with this disease.

338. *DIGITALIS.*—There is indubitable proof that this drug not only induces a diminution of the calibre of the blood-vessels, thus increasing blood pressure, but that it also favors the contraction of involuntary muscular fibre generally, throughout the body.†

Dr. Handfield Jones says, "Kulp's account of the action of digitalis in inflammatory diseases, seems to prove that it induces arterial contraction, rendering the hands and feet cold."‡

A further or excessive degree of this contractile effect on the vascular channels, gives rise to vertigo, giddiness or syncope, and in animals, to tremors and convulsive movements: while among the other poisonous effects are dryness of the throat, vomiting, weakness of the voluntary muscles, and a feeble, intermittent pulse.‖

Besides these effects, which so far have an uniform character, digitalis notably produces more vigorous heart-beats, a firmer pulse, with increased vascular activity, absorption of serous effusions and increased renal secretion.§

339. These apparently contradictory effects have given rise to much speculation and to many theories as to the true action of this drug. What has to be accounted for is:—

(a.) The lessening of vascular activity in some cases.

(b.) The increase of vascular activity in others.

(c.) The apparently opposite effects on the heart:—the drug sometimes producing intermittency and at other times deserving to be called "a cardiac tonic."

We will consider these separately, in accordance with the theory of vaso-motor innervation presented in these pages, and see how far it affords an explanation of this problem.

(a.) In states of the system, with the arteries *not unduly dilated*, or only so to a moderate extent, digitalis, acting as we have seen aconite and other drugs of this group to act—with differences to be pointed out hereafter—lessens the activity of the vaso-motor nerves, reduces the calibre of the vessels, diminishes blood supply and less-

*Pharmacodynamics, p. 149. †Dr. Dickinson, Med. Chirur. Trans., Vol. XXXIX.; Braith. Retros., July, 1864, p. 47. ‡Braith. Retros., January, 1869, p. 75; also ditto, p. 274. ‖Dr. Pereira, Mat. Med., vol. 2, p. 458. Dr. Robertson, Braith. Retrospect, July, 1864, p. 48. §Braith. Retros., Dr. Reith, January, 1869, p. 73. Ibid, Dr. Fothergill, July, 1869, pp. 80, 81.

ens vascular activity. This is the first mode of its operation referred to above.

(b.) When the muscular walls of the heart and arteries are defective in contractile power, unable to overcome the influence of their dilating nerves, and consequently remain *immoderately dilated*, digitalis by reducing the proportionally undue activity of these nerves, by partially paralyzing them, restores the normal balance of power between these opposing forces, gives the preponderance to the contractile efforts of the muscular fibres of the cardiac and arterial walls, in the manner so frequently indicated, and in this way brings about more vigorous contractions of the heart and a greater or less degree of reduction in the calibre of the vessels, which in their now more tense and elastic state transmit the blood with more force and rapidity than before :* improving the pulse, increasing the temperature, promoting absorption of effusions and favoring a return of the normal secretions, with increased elimination by the kidneys of the fluid previously effused.

Thus digitalis, which, in the other case, really lowered the circulation, here as certainly quickens and improves it : but in both cases through the same quality of its action ; the difference being in the different condition of the vascular apparatus acted on in each case.

340. The two conditions just discussed find their parallel in Dr. Withering's observations. Writing of the effects of digitalis on the kidney in producing diuresis, he says : " It seldom succeeds in men of great natural strength, of tense fibre, of warm skin, of florid complexion, or in those with a tight or cordy pulse."† Why ? Because in such subjects the development of muscular fibre in the arterial walls, as well as elsewhere, is such, that undue dilatation of these vascular channels is so strongly opposed that it is not likely to occur. The effect of digitalis in so far as it reduces their calibre, is simply to curtail vascular activity still more : and Dr. Radcliffe's physiological law, already quoted, is to the effect, that diminished blood supply necessitates lessened secretion.

Dr. Withering adds, " On the contrary, if the pulse be feeble or intermitting, the countenance pale, the lips livid, the skin cold, the swollen belly soft and fluctuating, or the anasarcous limbs pitting readily under the pressure of the finger, we may expect the diuretic effects to follow in a kindly manner."‡ Here, the muscular fibre of the arterial walls, is weakened or relaxed, permitting excessive dilatation of these tubes. Digitalis produces a "tightening" of these flabby channels, and with this, an increased rapidity and force of the circulation ; transmitting more blood through a given point in the same time than before. An impetus is thus given both to

*Dr. Carpenter's Physiology, p. 485. †Dr. Pereira, Mat. Med., Vol. II., p. 462.
‡Ibid.

nutrition and secretion, which in the other case were retarded or arrested; though in both, the mode of action of digitalis was precisely the same.

341. It is in the class of cases last indicated that digitalis best displays its power. Our theory points out how this result is achieved. By withdrawing—paralyzing—the restraining power of nerve-force over the inherent contractile power of the muscular fibres of the arteries, the latter are enabled to exert their proper function of reducing the calibre of the dilated vessels to a more normal size, with the effects just stated, of increased arterial tension, improved circulatory activity and its concomitant results.

342. *(c.)* We have yet to notice the third of the series of apparently antagonistic effects of digitalis, namely, its sometimes producing intermittency and at other times increasing the force of the heart's contractions.

We have seen how the effects of digitalis on the general circulation differs, in the different condition of the blood-vessels themselves. Let us apply the same conditions to the heart. In the person of tense fibre, or where the coronary arteries are a little more than ordinarily contracted, digitalis, by contracting them still more, and thus diminishing the proper blood supply to the cardiac tissue, lessens the nutritive activities on which the heart's movements depend: and, if administered in sufficient quantity, may prove dangerous by a threatened arrest of its action. (§ 246.) Hence its feeble, hesitating, or intermittent action, sometimes produced by digitalis.

On the contrary, where the systemic vessels, generally, are enfeebled or relaxed, or where the semi-lunar valves are unable to close the expanded orifice of the aorta, and a regurgitation of blood takes place, into the ventricle, weakening the force of the blood current, which consequently becomes sluggish, *the nutrition of the heart suffers* as well as that of more distant organs. The delicate cells, in which nerve-force is generated, on which the continued action of the heart's mechanism depends, have their functional activity reduced, and irregularity and intermittency of its pulsations follow as a consequence. Digitalis, by restoring the normal calibre of the vessels, puts an end to this unhealthy condition, at least in ordinary functional cases, where the derangement is not too extreme to be remedied; assists the more complete closure of the aortic valves; induces more vigorous changes in the heart's tissue, and, as a result, improves its propulsive power; a species of improvement which once begun tends to perpetuate itself.

Here, again, the mode of action in both cases is the same, so far as the drug is concerned. The effect exerted on the vascular nerves throughout is one of uniform paralysis, giving preponderance to the muscular fibres of the cardiac and arterial walls.

343. Other remarkable effects of digitalis remain to be noticed. Dr. Fothergill, in poisoning a frog with aconite, found "the ventricle become more and more distended, its contractions slower and more feeble, until each contraction drove only a small quantity of blood off the top of the distended ventricle, and at last, the greatly distended heart ceased to beat. At this crisis he administered digitalis, and soon contractions at long intervals took place imperfectly; the gaps became shorter and shorter and the contractions more and more complete, until the heart beat naturally."* Aconite, however, failed to dilate the heart of the frog contracted by digitalis.

The similarity and difference between these two drugs may be thus stated. Both paralyze the vaso-motor nerves, but at different points of the nervous circuit: the action of aconite being exerted at the periphery, and of digitalis at the central nervous ganglia, including the cardiac, dilating, nerves. These last being paralyzed, the heart becomes contracted, owing to the inherent contractile power of its muscular tissue finding itself no longer opposed.

The heart is more choked with blood in poisoning by aconite, owing to the generally contracted state of the entire terminal arterial system: the blood occluded from the lesser vessels of that system, overfills the larger vascular tubes, and especially the heart, as its chief reservoir. In the case of digitalis, it is the large vessels which proportionately are most contracted, owing to the impression of the drug being greatest on the central and cardiac vaso-motor nerves: consequently these contain less blood, and the terminal arteries more, than in poisoning by aconite. This explains the advantages of the latter over digitalis, as well as over belladonna in congestive and inflammatory states, in which the arterioles and capillary system play so important a part; though both drugs cause an increase of blood pressure, owing to the tension produced on the vessels, through the action of one drug centrally and that of the other peripherally.

344. Dr. Dickinson has pointed out,† and Dr. Archibald Reith confirms the statement, that digitalis, "in full doses, induces violent uterine contraction; checks uterine hæmorrhage and menorrhagia, and that the effect is permanent.‡

This remarkable power of producing contraction in both striated and non-striated muscular fibre suggests a similarity of its action to that of ergot. If our theory were to be sustained, and the heart admitted to be dilated by its motor-nerve force, and contracted through the inherent power of its muscular walls, a solution of the action of digitalis on the frog's heart would be found, consistent with its paralyzing action on the nerves, and consistent, too, with the similar mode of action attributed to ergot on the nerves of the uterus, permitting contraction of that organ. (§ 184.)

* Dr. Ringer's Therapeutics, p. 409. † Medico.-Chirur. Trans., Vol. XXXIX.
‡ Braith. Retrospect, January, 1869, p. 74.

345. In reference to the very large doses of the tincture of digitalis, which may be taken not only safely, but sometimes with apparent advantage, it has been suggested that perhaps the dilute alcohol of the tincture may to some extent antidote the full effects of the drug; since doses of the infusion, of relative strength, may not be administered without risk of dangerous effects.*

346. *CONIUM* belongs to the same group of paralyzers of nervous tissue as the drugs already considered. The cerebrum and sensory nerves are generally but slightly affected by it. Its paralyzing action is chiefly exerted on the motor nerves. The alkaloid conia is one of the most active and powerful poisons; being in this respect scarcely second to prussic acid, (Guttman) and yet some vegetable feeders, as the goat, sheep and horse, are said to eat hemlock with impunity.†

347. On the popular view of strychnia poisoning, a drug like conium, which so completely paralyzes the motor nerves, should be found a valuable antidote to the spasms of that state. Such is not at all the case, however; as was demonstrated by Guttman, who found it "failed to check in any degree the tetanic spasms produced by strychnia."‡ A fact like this is very unfavorable to the popular theory.

348. The death of Prof. F. W. Walker, of New York, in April, 1875, from three doses, of fifty minims each, of Squibb's fluid extract of conium, taken for the relief of facial spasms; and the circumstance of his dictating to his wife, who wrote for him, the progressive symptoms of paralysis, at intervals during two hours, and up almost to the fatal close, will long be remembered in the annals of this drug. *No mitigation of the spasms took place.* The danger of an erroneous theory is here apparent. If spasms and irregular muscular contractions were recognized as depending on a deficiency, rather than an excess, of nervous energy, measures calculated to cause a further depression of nerve-force would be prohibited in such a case, instead of being prescribed by the medical adviser, who in this instance acted in accord with popular teaching, and must be held blameless.

349. The action of conium, in accordance with our theory, is easily understood. By paralyzing the musculo-motor nerves, the muscles become incapable of responding to the will; not because the contractility of the muscle is destroyed, but because the nerves which form the medium of communication between the brain and the muscles are no longer capable of transmitting the molecular change necessary to induce contraction of the muscular fibre. (§77.) As a proof that the vaso-motor nerves are affected by conium, Dr. Ringer says, "the arteries of the frog's foot fail to contract on irri-

* Dr. Richard Hughes, Pharmacodynamics, p. 268. †Dr. Ringer's Therapeutics, p. 437. ‡Ibid, p. 443.

tation, when the animal is poisoned by hemlock."* Why? The "irritation" referred to is doubtless faradization, and if the latter were a "stimulus" to nerve-force, even the paralyzed nerves might be expected to make some response. But if electricity be a paralyzer, there is good reason why its application to the already devitalized nerves should fail to produce contraction of the arterial coats, since the contractile power of the muscular fibre of the vascular walls was already set free from the restraining influence of the nerves, and this effect of the action of electricity was already anticipated by the paralyzing action of the conium.

350. Dr. Ringer adds, "the motor nerves of some other involuntary muscles are uninfluenced by conia, as the peristaltic contraction of the intestines of the rabbits killed by the alkaloid, continued active after death."† This is to be accounted for by the fact that the nervous supply of the intestines is almost, if not entirely, derived from the sympathetic, which from its peculiar relations in the body, and the effect of its ganglia in retarding the transmission of impressions, doubtless is but slightly influenced by this poison. The vaso-motor nerves, indeed, pass through the ganglia of the sympathetic, but they originate in the cerebro-spinal system, and are more amenable to the influences which affect the latter than the former.

Conium, then, by paralyzing the vaso-motor nerves, sets free the contractile power of the muscular fibre of the arterial walls, lessening their calibre, diminishing blood supply, and with this, arresting the secretions of various glands. Hence, its reputed effects in dissipating enlargements and indurations of these structures; as well as in causing wasting of the mammæ and testes. It was formerly prescribed much more than at present, in coughs from an irritated condition of the air passages, where its mildly paralyzing effect, in suitable doses, fully accounts for its alleged utility.

351. A great deal of confusion has arisen owing to one species of hemlock being mistaken for another, and from the not unfrequently mixing of the several species.

352. It may be objected, that, on the theory here presented, the voluntary muscles should pass into a state of spasm and contraction, on the paralysis of their motor nerves, by conium, since the restraining power of nerve-force has been withdrawn, and muscular contractile power is free, and should produce its characteristic effects. This is really the case in some examples of poisoning by conium in man, but especially in rabbits and other inferior animals, although not in frogs. (Ringer.) For a reason why muscular contractions need not invariably, or necessarily, attend motor paralysis, we refer the reader to our exposition of why spasm or contraction does not speedily follow the severing of a motor nerve by wound or injury, in sections seventy-four to eighty-five of the preceding pages.

* Therapeutics, p. 440. †Ibid.

353. *HYDROCYANIC ACID.*—This deadly poison apparently kills by paralyzing first the brain, then the spinal cord and motor nerves. It produces its effects with great rapidity. Where death is not too quick in overtaking the victim, spasms and convulsions usually occur. After death the arteries are found empty and the venous system engorged with blood.

What is the condition of the cranio-spinal nervous centres here? Dr. Pereira states, "Whatever it may be, it is probably identical with that which occurs during an epileptic paroxysm, and that which is *produced by loss of blood;* for the essential symptoms, insensibility and convulsions occurring suddenly, are the same in all these states; and ammonia [a stimulant] has been found to relieve them."*

354. It seems strange that such a prompt and profound paralyzer should ever have been regarded as an excitor of any part of the nervous system. Yet it produces spasms, resembling those of epilepsy, and if this condition depends upon excitement of the nervous centres, and a consequent excess of nerve-force, why the conclusion is inevitable that prussic acid is a stimulant! Absurd as this conclusion is, and untenable as is the hypothesis on which it is based, it is fully in accord with the accepted theory of the proximate causes of spasm and convulsion, and even continues to be asserted by medical writers in recent times, one of whom says, "It seems to excite the whole motor tract of the cranio-spinal axis."†

355. The principal medicinal use of hydrocyanic acid is for the relief of nervous gastrodynia, with or without pyrosis: also, when irritability of the stomach,—probably of nervous origin,—causes vomiting. Dr. Pereira mentions a remarkable cure of periodic pain in the bowels by a few five minim doses of the dilute acid.

Its effects, in these cases, are doubtless attributable to its benumbing influence on the nervous centres, or on the sympathetic branches of the solar plexus.

356. *BROMIDE OF POTASSIUM.*—The sedative effects of this salt over the nervous system is too well known and too generally recognized to need demonstration. The effects of its prolonged use on the mental faculties are seen in drowsiness, mental languor, listlessness, confusion of intellect, impaired memory, lustreless eyes, depressed spirits, etc. On the motor nerves, its results are weakness, tottering gait, physical languor, restless and fitful movements, twitching of the fingers, and other indications of depressed power. Its effects on the sensory nerves are still more marked, as seen in partial anæsthesia of the integumentary and mucous surfaces; especially the insensibility of the pharynx to impressions which ordinarily excite reflex action. A lowering of sexual activity, especially when unduly excited, is among its general sedative effects. The

*Mat. Med., Vol. II., p. 788. †Dr. Richard Hughes, Pharmacodynamics, p. 23.

occasional emaciation, fœtid breath, acne-like eruption and other signs of mal-nutrition, seem to point to depression of those nerves which are believed to preside over the nutritive functions.

357. This drug exercises a no less potent influence over the heart and arteries. It lessens vascular activity generally, and tranquilizes the circulation. In excited conditions of the brain this effect is well seen. "The flushed face, the throbbing of the carotids and temporals, the suffusion of the eyes, the feeling of fullness in the head, all disappear as if by magic under its use." So says Dr. W. A. Hammond, who finds the blood-vessels of the retina contracted, and cerebral anæmia produced from its action on the heart and vaso-motor nerves.* Similar effects are produced on the circulation generally as are witnessed in the arrest of the secretions, the cure of gonorrhœa and clap ;† the reduction of the pulse and temperature in fever, of which the journals contain abundant proof.

358. Is the influence here exerted on the vascular nerves one of excitation or depression ? Apart from other considerations, it will be readily conceded, that consistency of action reqiures that a drug which depresses or paralyzes the brain, the motor, sensory, and trophic nerves, should also similarly affect the vaso-motor system. But as we have just seen the arteries are *contracted* under its use, and on the accepted vaso-motor theory, arterial contraction is due to vaso-motor excitation. Then, if that theory be correct, this drug, while depressing or paralyzing all other parts of the nervous system, excites the vascular nerves! We leave to the advocates of that theory the duty of explaining this anomaly.

359. The theory advocated in these pages presents no such difficulty. The vaso-motor, as well as all other nerves, are functionally depressed, lessening their restraint over the muscular walls of the arteries, which proportionately contract by their own inherent power, and thus produce diminished vascular activity.

From the foregoing considerations, the beneficial effects of this drug in excited, febrile and congested states of the brain or other organs, will be fully apparent, and need not be further dwelt upon. The relations of the bromides to epileptic and other convulsions, however, call for further remarks.

360. In previous pages, (§ 98) strong evidence has been produced to shew that the onset of the convulsive seizure depends essentially on anæmia of the brain. We have just now shewn that the bromides lessen vascularity, diminish blood supply, and so tend materially to produce an anæmic condition of that organ, and yet the bromides are among the favourite and successful remedies for the treatment of epilepsy.

361. But if the bromide of potassium produces cranial anæmia, and that is the condition on which convulsions essentially depend,

* Diseases of the Nerv. Syst., pp. 56, 65-6. †Braith. Retros., July, 1874, p. 191.

how is the bromide curative of that condition? This enquiry is not so embarrassing to us as it might at first sight appear; for this drug does not cure all kinds of convulsions: indeed, it not only fails to cure, but actually aggravates a certain proportion of the cases. Dr. Hammond declares it to be "exceedingly injudicious to administer any of the bromides in cerebral anæmia," for the reasons stated, and reiterates the warning more than once. In nineteen of his cases in which the condition of his patient was aggravated, all were of the nocturnal form, and the aggravation doubtless was attributable to the fact that during sleep the brain is already anæmic. In one of these cases the convulsive attacks resulted from the direct effects of the drug. Again, "M. Guerin did not consider the bromide of potassium a merely inoffensive remedy, as it has given rise in his hands to *nervous accidents resembling epilepsy*."*

The following considerations, we think, will account for the success and failure of the bromides in the disease in question. There is a condition of the circulation, in the cranio-spinal centres as elsewhere, in which the vessels are unduly relaxed, and their flabby walls distended with blood. Here, the blood current is sluggish and unequal; the interchange of new and effete materials between it and the nervous tissue is not conducive to the nutrition of the latter. Blood is there in sufficient quantity, but it is there under circumstances which are abnormal, and which, practically, are equivalent to its absence. We see a similar state in the sluggish circulation of the œdematous limbs, which nevertheless are cold and feeble; and we have also noted the effects of digitalis in contracting these flabby tubes and the beneficial effects of the consequent propulsion of the blood current at a more rapid rate, in the disappearance of the œdema, and the restoration of healthy nutrition and activity.

362. According to Dr. Beale, it is the sluggish blood current in fever, and the undue growth of unhealthy bioplasts it encourages, which cause the rise in temperature: the cure for which he holds to be the inducing of a more active movement in the circulating fluid.† In consequence of these effects of the sluggish blood current, in the unduly relaxed vessels, the oppressed brain is wakeful, perhaps delirious, and the outward manifestations of this condition are interpreted as excitement. The bromides cure this condition, in the same manner as digitalis improves the languid circulation in the œdematous limbs. By a paralyzing influence over the unduly active vaso-motor, dilating, nerves, it restores the balance of power to the antagonists of these nerves, the muscular fibres of the arterial walls. The calibre of these tubes is reduced to normal proportions; the blood current is accelerated; fresh pabulum is imbibed by the languishing nerve-cells of the ganglia, whose effete particles are swept onwards to be oxydized: in this way nervous vigor is

*Med. Times and Gazette, Vol. I., 1864, p. 96. †Disease Germs, p. 328.

restored, the control of the motor nerves over the muscles is re-asserted, and the convulsions arrested. Such, it is reasonable to assume, are the immediate phenomena of the curative action of the bromides in cerebral excitement and convulsions, and such the class of cases in which it proves beneficial. But when the condition of these vessels has become one of more or less chronic dilatation,* the remedy must be continued, and hence the bromide becomes, as one writer says, "the daily food" of the nervous centres, till after its long use they permanently recover their tone. The first departure from the normal state is the excitation of the vaso-motor centre, or nerves of the cranium, by some cause operating in the brain or some distant organ: undue vascular dilatation is set up as a consequence, and the cause continuing, of course it tends to perpetuate itself, and the consequences which attend this state.

363. In other cases, the vaso-motor nerves are not excited, but depressed or paralyzed, by the central or reflex cause; and, as a result, the vessels instead of being unduly dilated, become spasmodically contracted, depriving the nervous ganglia of their necessary nutrition. Convulsions result, as in the former case, and from the same proximate cause, though induced in a manner the very opposite. "By contraction of the vessels, the brain is deprived of blood, and consciousness is arrested; the face is or may be deprived of blood, and there is pallor; by contraction of the vessels which have been mentioned, there is arrest of respiration, the chest walls are fixed, and the other phenomena of the first stage of the attack are brought about."†

Here, the bromides cannot be expected to cure, but will rather aggravate the malady. Stimulants and food medicines, such as strychnia, phosphorus, iron, and nutrients, ought best to meet the conditions; and such is found, practically, to be the case. Strychnia is a very valuable remedy in epilepsy. Dr. Hammond generally combines it with the bromide in doses of from the thirty-second to the twenty-fourth of a grain, "for the purposes of a tonic, and for counteracting to some extent the debilitation produced by the bromide."‡ Dr. Brown-Sequard also advises this combination, but admits that the bromides and strychnia mutually counteract each other, so that where these agents are used together, the dose of the bromides must be increased.‖ Would it not be wiser to give each separately, in the condition for which it is adapted, and in smaller doses?

364. Dr. Marshall Hall recommended strychnia in threatened epilepsy; and Dr. Walter Tyrrell, of London, "who has watched the effects of strychnia upon various forms of epilepsy, has no hesitation in affirming that in a large majority of cases its effects are most beneficial."§

* Dr. Hammond, Dis. of Nerv. Syst., p. 578. † Dr. Reynolds, Treatise on Epilepsy, &c., p. 238. ‡ Diseases Nerv. Syst., p. 583. ‖ Naphey's Mod. Therapeu., p. 39. § Ibid, pp. 41-2.

Dr. Hammond has found the treatment by strychnia "satisfactory" in a number of cases, and in these there were no relapses. He thinks it is more effectual in the nocturnal than in the diurnal form of epilepsy; that is in the anæmic form, the condition the reverse of that benefitted by the bromides. Of course the reader will not here confound the tonic or "food action" of strychnia with that of its effects in poisonous doses, which are so entirely different.

It is in this class of anæmic cases that cures have been effected by stimulating agents: in one instance by assafœtida and carbonate of ammonia; frequently from inhalation of chloroform or æther to a moderate extent: and, in short, wherever stimulants to nerve function have been found beneficial, which is no small number of the whole.

365. It is difficult, in many instances, to determine the state of the cranial circulation, as a guide to one or other of these classes of remedies. But it may be regarded as a rule, that whenever the pupil is dilated, cerebral anæmia is present, and that stimulants will be found beneficial. Contraction of the pupil, on the contrary, implies, at least, hyperæmia of the iris, and probably also of the cranial mass; but this need not necessarily be active, and is often venous.

Bromide of potassium first attracted marked attention as a medicine in the cure of enlargements of the spleen. It has cured ague after the failure of quinine. Cases of gonorrhœa and gleet have been reported in which its use has proved successful. Of the bromides, this one has proved most successful in the treatment of epilepsy.

366. The same general theory of action will be found to apply to the bromides of ammonium, sodium and lithium. They are all sedatives and depressants to the general nervous and vascular systems. The bromide of ammonium appears to possess some special influence over the nervous and vascular system of the uterus, and is of special value in arresting menorrhagia. The bromide of lithium contains a larger percentage of bromine than the other salts mentioned, and is credited with greater hypnotic powers. (Dr. Ringer.) It is very expensive. Dr. Hammond thinks "the bromide of sodium is more readily assimilated, is less apt to produce gastric irritation, but in other respects its action is similar to that of the corresponding potassium salt."

367. Dr. C. B. Radcliffe suggests that much of the good effect of these preparations is due to their depurative action on the blood, especially in the case of epileptics who are prone to gorge themselves with an excess of food. Like other potassium salts, he thinks they assist in eliminating effete materials from the blood, and that

they thus contribute to healthy assimilation and nutrition, and in this way exert a beneficial influence over the disease.* The fœtid breath, pustular or carbuncular eruptions, and mental and physical debility which attend the prolonged use of these drugs, do not seem to favor this view of their action.

368. *HYDROBROMIC ACID* is a more recent acquisition in medicine. It is prepared by the action of tartaric acid on bromide of potassium dissolved in water, in the following proportions :—Dissolve ten ounces of potassium bromide in four pints of water, and add thirteen ounces of acid tartaric. The hydrobromic acid remains in solution, and potassium bitartrate is precipitated. It has all the properties of bromide of potassium, and promises to be a useful and agreeable sedative in excited or unduly vascular states of the brain or other organs, including tinnitus aurium of congestive origin. The dose is from half a drachm to a drachm in water as needed.

369. *CANNABIS INDICA.*—Indian hemp is another remedy of this class. It is often of marked use in menorrhagia, in doses of from twenty to thirty drops, two or three times a day, according to the urgency of the symptoms.† It has been recommended in combination with bromide of potassium in mania. It doubtless produces its sedative effects on the circulation in the same manner as the remedies hitherto noticed.

370. *ERGOT OF RYE.*—See special chapter devoted to this drug, owing to its importance in the general discussion of the contractions of muscular tissue.

371. *QUININE SULPHATE.*—We have already alluded to this invaluable drug as an aid to parturition, in treating of ergot, (§ 186) and to its influence over the nervous and vascular systems, in discussing the adaptation of this theory to the febrile state. (§ 236.) There is but little to add here, in reference to a drug whose general uses are so well known ; and we content ourselves with what has already been said of its general action under the theory here presented.

372. *ARSENIC.*—As a poison, some of the effects of arsenic entitle it to a place here, but as a food-medicine, it belongs to the next series of drugs ; to which the reader's attention is directed.

373. *PLUMBI ACETATIS.*—The profession is indebted to Dr. John Stephenson, of Montreal, for the discovery, and mainly to Dr. J. Workman, of Toronto, for the promulgation—formerly in his lectures to his class, and recently in a published paper‡—of the fact that acetate of lead in doses of half a drachm or more, repeated according to the urgency of the case, is a safe, prompt and effectual

* Lectures on Epilepsy, &c., p. 203. † L'Union Medicale, Montreal, 1872, p. 56.
‡ Read before the Canada Medical Association at Montreal, Sept., 1877.

remedy for post partum and other hæmorrhages. The acetate should be pure, the crystals bright, and not in the floury state, indicative of the carbonate of lead. It should not be combined with acetic acid or opium, as formerly recommended, but be administered alone, with the aid simply of a spoonful of water. It has been given in teaspoonful doses, in uterine hæmorrhage, not only without injurious consequences, but with positively beneficial effects of a most gratifying kind. It is equally applicable to hæmoptysis, and hæmorrhage from other organs. In the doses mentioned, having exercised its anti-hæmorrhagic effects, it is extruded from the bowels, by a gentle purgative process.

374. What is the modus operandi of its action? According to Dr. Pereira, "it is administered internally to diminish the diameter of the capillary vessels, and lessen circulation, secretion, and exhalation."* This can only be accomplished through the agency of the vaso-motor nerves, as Physiology teaches. Dr. Workman writes, "I do not believe we have in all our materia medica, a more prompt or potent promoter of uterine muscular contraction." Here is an implied action upon the motor nerves. Assuming that the drug acts upon both the vaso-motor nerves, in its action on the blood-vessels and on the motor nerves, in its action on the muscular tissue of the uterus, in what manner are these two systems of nerves impressed? Are they functionally stimulated or paralyzed?

375. A glance at the paralyzing effects of this and the other salts of lead will not favor the idea that it can assist in promoting the nutritive process in those cells in which nerve-force is generated. Thus, among the poisonous effects of the acetate, are great prostration of strength, cramps of the extremities, cold sweat, giddiness, numbness and even paralysis of the lower limbs and sometimes coma.† This last state is attributed by Dr. Carpenter to paralysis of the sensory ganglia.

Among the earliest symptoms of lead colic, before any of the local effects are fully developed, are "more or less depression of the nervous functions, despondency, mental debility, and a disinclination to either mental or physical effort, with a feeling of wretchedness and gloom. . . . There is a sense of weakness, a sinking, collapsed feeling in the epigastrium. . . . The bowels are really in a state of permanent muscular contraction."‡

376. If these are the effects of poisonous doses, have we any right to conclude that the drug administered in teaspoonfuls, acts the part of a tonic, or increases nerve-force so as to furnish an unusual "stimulus" to muscular contraction? On the theory here advocated, the acetate of lead paralyzes the motor nerves, and proportionately sets free the muscular contractile tissue of the uterus, intestines, &c., which passes into a state of contraction accordingly.

*Mat. Med., vol. I, p. 710. †Dr. Ringer, Therapeutics, p. 174. ‡Drs. Jones and Sherwood, Prac. of Med., Vol. I., p. 703.

By a similar paralyzing effect on the vaso-motor nerves, the muscular coat of the arteries is permitted to contract; shutting off blood supply, and arresting hæmorrhage. This view of the case is not based upon a single fact, but upon a whole series of facts, to which the preceding pages bear witness. To these accumulated proofs we have nothing further to add in this connection.

377. *OXIDE OF ZINC.*—The mode of action of this drug is similar to the last, and to the medicines of this class. It acts as a sedative to the vascular system, checks secretion, &c., in a less degree, however, than the acetate of lead. Dr. W. A. Hammond classes it among remedies which produce cerebral anæmia, drowsiness, faintness, pallor of face, &c., and administers it in two grain doses, three times a day, in cerebral congestion.*

378. It has been recommended for diarrhœa in children; and in appropriate cases, namely, those of a congestive type, or depending on undue nervous excitation, it would be advantageous; but probably not more so than other drugs which tend to bring about vascular contraction, diminished blood supply, and the effects of these changes, lessened secretion in the intestinal tract. It may sometimes be advantageously combined with pepsin or bismuth.

379. *SULPHATE OF ZINC.*—This drug is also a type of the general class we are now considering. In moderate doses, it lessens the activity of the vaso-motor nerves, giving the preponderance to the antagonists of these nerves, the muscular fibres of the vascular walls, and so causing diminished blood supply and lessened secretion.

A further degree of its action leads to paralysis of the motor centres or nerves, which normally restrain the gastric muscle, the stomach; vomiting ensues as a consequence. It is a useful emetic where it is desirable to avoid much depression. Dose for this purpose, from 10 to 20 grains for an adult.

380. *PHYSOSTIGMA, or CALABAR BEAN.*—The experimental investigations of Dr. Frazer, of Edinburgh, have led him to the conclusion that this drug first paralyzes the spinal cord and soon after the motor nerves. Consequently,—in accordance with the popular theory—he anticipated that physostigma would prove highly valuable as an antidote to strychnia. This hope has not been realized: for while calabar bean "modifies strychnia tetanus," . . . . "so far from saving life, it actually aids its destruction, for when both poisons are administered together, but each in quantity less than the minimum fatal dose, their combined action in this dose will destroy life."† We see in this fact, a proof—in addition to what has been said in previous pages—that the spasms and convulsions of strychnia are not due to *excitation* of the cranio-

* Diseases of Nerv. Syst., p. 57. †Dr. Ringer, Therapeutics, pp. 503-504.

spinal centres; otherwise so profound a paralyzer of these centres could not fail to antidote them.

381. This drug has, in recent years, been popular in the treatment of tetanus. Owing probably to variations in the strength of the preparation used, and to the susceptibility of patients, the dose has varied from one-fourth to two and even four grains—for a short time—of the extract every hour.*

In a former reference to tetanus, (§ 118) we quoted statistics of this disease, showing that while calabar bean had proved curative in thirty-nine per cent. of the cases, other drugs shewed a more favorable record, and the treatment by stimulants alone showed a curative result in no less than eighty per cent.—the highest on the list.†

This is a very striking result from a class of remedies whose action is precisely the reverse of that attributed to calabar bean; and naturally leads to the enquiry, how far were the beneficial results of the latter attributable to the paralyzing influence of the drug. Dr. Ringer has no doubt upon this point, for he says, "it is generally, nay probably always, necessary to produce a certain degree of paralysis amounting to heaviness of the limbs;" and again, "to be of any use, it must be given in quantity sufficient to produce paralysis . . . indeed to such an extent that but a little more would permanently arrest the breathing."‡

382. On the other hand, it would appear as if certain of the elements of calabar bean are antagonistic to each other. Thus a recent writer states, "The alkaloids of this drug, upon which its virtues depend, are eserina or physostigma, and calabarin, which acts like strychnia. . . . It sometimes occasions in frogs, tetanus, probably due to the calabarin:" and again, referring to its use in tetanus, it is said, "care must be taken that it contains no calabarin, which tetanizes."‖

383. We have already remarked that in by far the greater number of reported cases of tetanus treated by calabar bean, not only nutrients, as broths, etc., but even stimulants are freely administered; though why stimulants should be admissible at all, if the disease depends on undue excitation of the nervous centres, is a question for the advocates of the popular theory to solve. We have seen above, the large percentage of cures by stimulants alone. How much of the good results attributed to calabar bean may be fairly allotted to the generous diet and free stimulation used in conjunction with it, is a question which in protracted cases, at least, is entitled to consideration. In numerous instances, the administration of the drug was followed by speedy and marked amelioration of the symptoms, as reported in the journals; but from the antagonistic effects of the alkaloids contained in the bean, as noted above,

*Braith. Retros.: Dr. Ringer. †Dr. W. A. Hammond, Dis. Nerv. Syst., pp. 540–1.
‡Therapeutics, p. 450. ‖Dr. Ott, Action of Medicines, pp. 137, 138.

it must be difficult to say whether the "paralyzing" or "tetanizing" effects predominated. Doubtless further light will in time be thrown on this part of its action. In the meantime, there is nothing in the reported relations of this drug to tetanus which can be quoted against us.

384. The same theory of the action of calabar bean which suggested its applicability to the treatment of strychnia poisoning and tetanus, led to its administration in chorea. Dr. W. H. Fuller, physician to St. George's Hospital, London, who has tried it in this disease, in seven consecutive cases, beginning with ten minim doses of the tincture, three or four times a day, and increasing the doses till the characteristic poisonous effects began to be produced, reports unfavorably of the result. He says "the pulse became accelerated, feverishness supervened, loss of appetite and vomiting ensued, and uneasy sensations were complained of in the head. A drachm and a half or two drachms of the tincture taken three times a day usually sufficed to induce these symptoms. Beyond this, no appreciable effect was observed. There was no evidence of the accumulative action of the drug; it did not appear to influence the secretions; it did not materially affect the pupils, and it certainly did not exercise the slightest influence over the disease." Dr. Fuller concludes it has no value as a curative agent in chorea. The tincture administered was made by macerating one drachm of the powdered bean in one ounce of rectified spirit.* Here again the popular theory is out of joint with practical results.

385. We have now to note a different application of calabar bean. Dr. Crichton Browne finds it remarkably useful in general paralysis of the insane, and has effected cures of such cases with it. Dr. Ringer vouches for its value in such states as general paralysis, progressive muscular wasting and chronic hemiplegia, in doses of one-thirtieth of a grain of the extract every two hours. Also in paraplegia, in one-tenth grain doses, and in locomotor ataxy.†

It has also proved curative in paralysis of the 3rd and 6th pair of cranial nerves; as shewn by a return of functional activity in the former towards the iris, and of both over the muscles of the eye supplied by these nerves. The drug here was used locally; one-fourth of a grain of the extract, made into an emulsion with a few drops of water, freely poured into the eye.‡

These results shew that this drug, like some other poisons, in small or moderate doses, by a species of food action, tends to increase the activity of the cells which generate nerve-force, and so to aid in its development.

386. Calabar bean increases arterial pressure, which is equivalent to saying that it contracts the arterial tubes, and consequently

* Braith. Retros., January, 1872, p. 65. † Therapeutics, pp. 451-2. ‡ Dr. T. Wharton Jones, F.R.S., Braith. Retros., January, 1870, pp. 149, 150. Practitioner, 1869, p. 160.

"tightens" the circulation within them. It is thus a vaso-motor depressant, as well as a spinal and motor nerve paralyzer. Notwithstanding this mode of its action, it usually causes a notable increase of the salivary, bronchial, intestinal and lachrymal secretions:* for the explanation of which, in the absence of arterial dilatation, see § 328.

387. Calabar bean dropped into the eye contracts the pupil, and in this it is the direct antagonist of atropia. Atropia here is a paralyzer of the vaso-motor—ciliary—nerves, which, when excited, dilate the vessels of the erectile tissue of the iris. (§ 254.) Paralysis of these nerves permits contraction of the muscular walls of the vessels of that tissue, a diminution in its size, and a consequent retraction of its pupillary margin. Calabar bean, on the contrary, by an action similar to that exerted in the cure of paralysis of the 3rd pair—noted above—or perhaps by a peculiar kind of local irritation, aids in the production, or calling forth, of nerve-force, increases the dilating power of the ocular vaso-motor nerve-fibres over the blood vessels, dilates the latter, flushes the erectile iris with blood, enlarges its bulk and so pushes its pupillary margin inwards and occludes the pupil.

This effect does not follow on the internal administration of the drug, for which fact M. Bourneville, of Paris, vouches, as the result of his experience on men, and experiments on animals.† The contrary, however, has been affirmed by some observers, as the result of its subcutaneous injection, where doubtless its paralyzing properties were markedly prominent; since, in one case of this kind, forty-one grains of the extract were subcutaneously injected in "a little more than twenty-four hours, the largest dose being six grains."‡

388. In its effects on the secretions, on the iris, and in some other respects, calabar bean is the antagonist of belladonna and atropia. But this antagonism is partial and not general. Thus, a certain dose of physostigma will be neutralized by a certain dose of atropia, but if the quantity of the former be increased beyond a certain point, atropia, in an increased dose, will not only not antidote it, but both together will hasten death.‖

389. The record of this drug is somewhat remarkable. Its action appears impossible to explain consistently with the popular theory of innervation. How the theory here presented accords with these facts, we leave the reader to determine. Its chief action as a paralyzer entitles it to be entered among the class of drugs we are now considering: while its curative effects in paralysis, and its influence on the iris, as certainly cause it to rank among the drugs of the next succeeding class.

*Dr. Ringer, Therapeutics, p. 471. †Braith. Retros., January, 1870, p. 50. ‡Braith. Retros., July, 1870, p. 47. ‖Dr. Ringer, ibid., p. 471-2.

390. *TARTAR EMETIC.*—This drug is a depressant to the heart, to the circulation, and respiration, quite independently of its nauseating effects.* Hence it is a sedative or paralyzer in its action on the nervous system; and doubtless through the quality of its action on the pneumogastrics, produces vomiting, in accordance with the view heretofore enunciated. It irritates and inflames the lungs, stomach and intestines, and increases secretion from the mucous surface generally and from the skin; effects attributable to its action as a tissue irritant. It produces these effects whether swallowed, absorbed from a wound or injected into a vein, and hence appears to have a special affinity for these organs (Pereira), which are doubtless the channels through which it is extruded from the system. It largely increases the excretion of urea (Ringer). Its effects as a local irritant to the skin are well known.

The depressing effect of tartar emetic on the circulation has caused it to be extensively utilized in the treatment of pneumonia, for which purpose Dr. Ringer recommends a grain to be dissolved in half a pint of water, of which a teaspoonful is to be given every quarter of an hour, for a few doses, and afterwards hourly. In emetic doses it produces great prostration; doubtless paralyzing other portions of the nervous tract beyond that immediately involved in this process. Hence it is rarely used for this purpose; other and less weakening agents being preferable for evacuating the stomach.

It does not appear necessary further to enlarge on the action of this drug; the neurotic side of its action being quite in harmony with our theory; while the foregoing glance at its tissue irritation must suffice.

391. *IPECACUANHA.*—Dr. Headland says of this drug that it "resembles antimony in all its operations except its blood action. It is less potent as a neurotic; less efficacious as a diaphoretic; but excels it as an expectorant."† Its effects over the vaso-motor nerves are seen in the reduced calibre of the blood-vessels, and the power it consequently exerts over hæmorrhages from various organs, for the arrest of which it has achieved considerable reputation;‡ as also in the treatment of dysentery, for which it has acquired the title of an "antidote."

392. A drug which diminishes vascular supply diminishes secretion, except in the case of some tissue irritants; and if this be the *rôle* of ipecacuanha, then its action as an expectorant ought to be, not to increase, but to diminish mucous exhalation from the bronchial tubes, and in doing so to render the residue more easily expectorated. Or else, by lessening the congestion of the bronchial mucous membrane, which when inflamed is abnormally dry, it favours a

*Dr. Headland, Action of Med., p. 376. Dr. R. Hughes. Pharmaco., p. 77. †Action of Med., p. 379. ‡Dr. Ringer's Therapeutics, p. 376. Dr. R. Hughes, Pharma., p. 340.

return of the normal secretion, a more ready expectoration, and so a return to health.

The same depressing effect which it is thus seen to exert on the vaso-motor nerves, by which the muscular coats of the arteries are permitted to contract, is also seen in the motor nerves supplying other contractile organs. Thus, a very distressing constriction of the bronchial tubes occurs to many persons from simply inhaling the fine powder of ipecacuanha. The internal use of the drug is credited with producing occasional tenesmus of portions of the intestinal tube; effects which we attribute in both cases, as also the vomiting which is one of the characteristics of the drug, to the depression of *motor* nerve-force, setting free the contractile power of the muscular fibres of the walls of these viscera, just as the depression of the vaso-motor nerves is attended by similar effects in the walls of the arteries.

As an emetic, ipecacuanha produces its effect without the deadly prostration attending the use of tartar emetic. Five grains of the powdered root, in a little warm water, or from one to four drachms of the wine of ipecacuanha for an adult, for a child from twenty minims to a drachm, according to age, will suffice.

393. Dr. Ringer speaks highly of ipecacuanha spray and inhalation in winter coughs and bronchitic asthma. The wine of the drug is used for this purpose, diluted with water to one half or more, according to the susceptibility of the patient. Nausea ought not to be produced; and, to avoid this, frequent pauses are necessary, and also the spitting out of the accumulated spray.

394. The cure of functional vomiting by drop doses, or less, of vinum ipecacuanha, is one of the anomalies of drug action; of which contrarieties of effect between small and large doses examples are more numerous than is generally supposed. This fact is not a new one. It was pointed out about half a century ago by Hahnemann, and has been largely utilized by homœopathists, whose system, we have learned by experience, contains a substantial truth, but it has been unfortunately associated with a great deal of absurdity and extravagant notions.

If vomiting depends on depression of motor nerve-force, in those centres or nerves which ordinarily control the contractions of the stomach, as in former pages we have endeavoured to shew, the small doses referred to, for arresting functional vomiting, probably act by inducing dynamic changes which so modify the molecular motion of nerve-force in the nervous tubules concerned, as to favor relaxation rather than contraction of the muscles concerned.

The withdrawing of food and drinks for a time, and using them at first very sparingly, is an important and often an indispensible condition for the arrest of vomiting. If this condition be attended to, teaspoonful doses of a weak solution of bicarbonate of soda with

from one-thirty-second to one-sixtieth of a grain of morphia, every half hour or hour, will very often prove effectual. The dose of the latter must be too small to produce sedative effects; for when these are reached, as is well known, opium and morphia are very provocative of vomiting.

395. *MERCURY.*—Dr. Headland writes of mercury:—"By some inscrutable chemical power, of whose nature we know nothing, it is able to decompose the blood: by some destructive agency it deprives it of one-third of its fibrin, one-seventh of its albumen, one-sixth or more of its globules, and at the same time loads it with a fœtid matter, the product of decomposition."* It is no part of our task to follow the action of mercury on the blood or tissues. But it is pertinent to our subject to enquire, has it any action as a neurotic? Dr. Pereira says, "various symptoms indicating a disordered condition of the nervous system are met with in persons who have been exposed to the baneful influence of mercury; such as wandering pains, a tremulous condition of the muscular system, sometimes accompanied with stammering, and occasionally terminating in paralysis, epilepsy, or apoplexy."†

Dr. Ringer says further, "These tremors are easily excited, cannot be controlled, and persist for some time. In severe cases almost every part of the body is affected by severe spasmodic movements, so that respiration is spasmodic and the sufferer may be unable to walk, talk or masticate. Loss of memory, headache, delirium, and even convulsions may occur."‡

396. Now, on the theory popular with the profession, these spasms and convulsions denote an undue excitation of the nervous centres, and an excessive development or activity of nerve-force. But is this possible from the use of an agent which produces such deteriorating effects on the blood, and such obvious signs of nervous depression as loss of memory, delirium, etc.? Do not these last symptoms denote incipient cerebral paralysis, just as motor paralysis is to be seen in the tremors, spasms and other irregular movements of the muscles, which are in part released from their customary nervous control? An extension of the same depression to the vascular nerves, arresting their dilating power over the arteries, and permitting contraction of the muscular walls of these, constricting their calibre, and lessening blood supply to the terminal vessels, would serve to account, in part at least, for the occasional good effects of mercury in inflammatory states.

397. Among homœopathists, the bichloride of mercury in small doses, is extensively used in iritis, and in dysentery, especially with slimy, bloody, or shreddy stools. Dr. Ringer writes in strong terms of the great value of the bichloride in both of these diseases, but makes no acknowledgment of the source of his information, an

* Action of Med., p. 387. † Mat. Med., Vol. I., p. 773. ‡ Therapeutics, p. 200.

omission of which the present is by no means a solitary example. He recommends the one-hundredth part of a grain every hour, for an adult.*

398. But only a part of the effects or uses of mercury can be accounted for from its action as a hæmatic or neurotic. It is to its general and profound influence over the lymphatics, glands and secreting surfaces, that the greater portion of its effects must be attributed. It is hardly creditable to medical science at the present day, that leading authorities should be unable to agree as to the effects of mercury on the intestinal canal and its appendages. But that in small and repeated doses it increases the secretions from the entire alimentary tube is a fact verified by abundant experience. Is its action here, that of an irritant, forcing its way out of the blood through the agency of the excretory glands and cells, and setting up a state of temporary local hyperæmia in these organs as it is extruded through them?

We have nothing of importance to add to what has already been well written as to the general effects and uses of mercury arising out of its various modes of action. Moreover, as the pursuit of this part of the subject does not involve the issue it is the chief object of these pages to present, we content ourselves with this brief allusion to a drug which probably more than any other has brought honor and disgrace on the medical profession, and accomplished much good and evil to the human family.

399. *IODINE.*—The mode of action of this drug is involved in obscurity. Dr. Pereira regards it as a liquefacient of the fibrin of the blood.† Dr. Headland suggests that it destroys the albumen and fibrin of the blood, and that the tissues are called upon for the materials to supply the waste thus occasioned.‡ Dr. Richard Hughes attributes to it an action of a depressing character on the lacteal vessels and mesenteric glands.‖ According to Dr. Billings it causes contraction of the arterioles and capillaries, and thus starves the superfluous growths which it sometimes removes. Dr. Headland has pointed out that the tumours it dissipates are those of the scrofulous or syphilitic class, and quotes Dr. Ferguson (surgery) for the statement that "he has never in one single instance seen an organized adventitious growth removed by its means."§

400.—From the foregoing considerations, iodine cannot be held to be a tonic, or to aid in the development or manifestation of nerve-force. When, therefore, its excessive use occasions muscular tremblings, twitches, convulsions and paralysis, we feel justified in regarding it as a paralyzer of motor nerves: and from its other effects, in producing paleness, weakness, emaciation, etc., it appears equally certain that it depresses the vaso-motor nerves, reducing

*Therapeutics, pp. 196-7, 203. †Mat. Med., Vol. I., p. 215. ‡Action of Med., p. 397. ‖Pharmaco., p. 318. §Action of Med., p. 397.

the calibre of the blood-vessels, as Dr. Billings suggests, and by lessening the pabulum conveyed to the glands and tissues, impairs or arrests their nutrition.

401. This mode of operation, so far, is similar to the general neurotic effect we have attributed to mercury. Indeed, a comparison of the symptoms of iodism and mercurial fever would shew a similarity in many points. Both produce mental depression, anxiety and restlessness. Both render the pulse quick and weak. Both produce emaciation and weakness, but the emaciation of iodine is very much more rapid and extreme. Both are of marked utility in syphilis: gastric irritation is found to attend the excessive use of both. Both cause eruptions on the skin. Both influence very notably the mucous membranes of the nose, eyes, mouth, and fauces. Iodine produces little or no purging, while the increased secretions from the intestinal canal caused by mercury, are a prominent feature of its action. Both iodine and mercury cause salivation, but this is sometimes true of a number of other drugs, including Dover's powder, from which such a result could not be *a priori* anticipated.

402. It is well known that iodine is one of the remedies which exerts a favorable influence on the salivation of mercury. This apparent anomaly is accounted for by the fact that while the salts of mercury, and most other metals, form insoluble compounds with albuminous substances, these are very generally soluble in the chlorides, bromides, and iodides of the alkalies, but especially in the iodides. The iodide of potassium, then, re-dissolves these mercurial compounds, and so favors their extrusion from the system. In this way, a secondary salivation may be set up, owing to the return of the mercury to the circulation, prior to its elimination.*

From all that is known, then, of the mode of action of iodine, or of mercury, there is nothing in the facts connected with either, which militate against our theory, but much that is in accord with it.

Of the general uses of iodine and its preparations our text books generally furnish such complete details that an extended reference to these here is unnecessary, especially as most of these belong to its character as a tissue irritant, and so are foreign to our general purpose.

We might remark, however, what appears to be sometimes overlooked, that when the specific action of iodine is desired for the absorption of scrofulous or indurated glands, by topical application, it is best so to apply it as not to produce irritation or vesication; as otherwise the contrary effects may be produced to that intended.

403. *ALCOHOL* (as a narcotic).—This drug, as well as chloral hydrate, chloroform and ether, in small or moderate doses, is a stimulant

*Dr. Ringer, Therapeutics, pp. 79-80.

to nerve-force, increases arterial circulation and heightens functional activity. In this respect it belongs to the next series of drugs, yet to be considered, where this part of its action will be discussed.

We have here to study its effects in large, and yet (usually) non-poisonous doses, in which it is a narcotic, and paralyzes the motor, sensory and vaso-motor ganglia and nerves; examples of which action on its part are sufficiently numerous.

404. The effects of alcoholic inebriation are familiar to all, so far as their outward manifestation is concerned: but much difference of opinion has existed and still exists, as to the true pathology of this state. In accordance with the theory of these pages, the first stage, that of stimulation, appears with the flushed face (vaso-motor dilatation of the arteries) and other co-incident signs of increased mental, motor and vascular excitement. In certain excitable temperaments, this excitement may induce temporary insanity, under the influence of which crimes of violence are not unusual. In ordinary cases, the effects soon subside after the force of the drug has expended itself; but if the potations are continued, this stage is usually soon passed, and the thickened speech, altered manners, foolish loquacity, etc., betray the onset of cerebral paralysis, when the restraints ordinarily exercised over the man are withdrawn, and qualities are revealed, propensities displayed and indiscretions committed, which ordinarily he conceals or avoids.

As the narcotism deepens, paralysis of other portions of the brain becomes more or less apparent. Depression of the cerebellum, corpora striata, etc., displays itself in the staggering gait, inability to sit or stand, and finally in the extinction of the power of motion; a state in which the victim is sometimes spoken of as "dead drunk." There is also paralysis, to a greater or less degree, of the sensory nerves, as is shown by the reception of wounds and injuries in this state, which are unfelt, and of which no cognizance is taken, until the power of the sensory ganglia and their normal relations to the cerebrum are restored. The vaso-motor nerves, which are intimately associated with the circulation of the blood, share in this general nervous prostration. As we have endeavored to shew in previous pages, the lowering of the functional activity of these nerves, which ordinarily dilate the arteries, allows unrestrained sway to the inherent contractile power of the middle muscular coat of these vessels; and the result is a lessening of their calibre; in extreme cases, an occlusion of the smaller tubes, diminished supply of blood to the capillaries, a lowering of temperature, coldness, paleness, paralysis and sometimes convulsions, and even death.

405. Such, we think, is the true pathology of the case; although not precisely that presented by the authorities. Thus, Dr. B. W. Richardson divides the effects of alcohol into four stages. He says, "The first is a stage of excitement, when there exists that relaxa-

tion and injection of the blood-vessels of the minute circulation, with which we have become conversant. The second stage is the stage of *excitement*, with some *muscular inability* and *deficient automatic control*. The third is a stage of rambling, incoherent emotional *excitement* with *loss of voluntary muscular power*, and ending in helpless unconsciousness. The fourth and final stage is that in which the heart itself begins to fail, and in which death, in extreme cases of intoxication, closes the scene."*

What is objectionable here, is carrying the "excitement" into the second and third stages. The words we have italicised in this quotation, we think, will render it apparent to the intelligent reader, that in these stages there can be no excitement proper, or increased nerve-power, but rather a gradually deepening paralysis, beginning with "muscular inability" and progressing to "helpless unconsciousness," and death. As Dr. Anstie has shewn, any agent which thus severs the chain of co-ordinate power among the organs, is a devitalizing one, and tends to paralysis and arrest of function, more or less complete, of the nervous system. For it is not the muscular, but the nervous tissue, which alcohol assails, and in narcotic doses, weakens. As Dr. W. B. Carpenter remarks, alcohol has a special affinity for the nervous tissue, which it seeks out, as it were, and fastens upon: and of this tissue it is the cerebrum which is first assailed.†

406. Dr. Richardson writes again,—"In man and animals, during the period between the first and third stages of alcoholic disturbance, there is often muscular excitement, which passes for increased muscular power. The muscles are then truly more rapidly stimulated into motion by the nervous tumult, but the muscular power is actually enfeebled."

Here, the absurdity of the popular theory is again apparent. If muscular power be depending on a nervous "stimulus," and the muscles are being "more rapidly stimulated into motion by the nervous tumult," why is muscular power "actually enfeebled?" It is evident that the assumed "excitement" here is altogether fallacious; and that this view of the pathology of the case is untenable. See sulphuric æther, § 409.

We have to urge an entirely different theory of the condition presented. It is, that here muscular power is not itself enfeebled, or only influenced very indirectly, if at all, by alcohol. The muscles are as strong as ever, but their motor nerve centres are paralyzed in the brain, from which, in consequence, they are physiologically severed. The muscles would pass into a state of contraction, were it not that alcohol, in expending its chief force upon the brain, spares for a time, or in some cases altogether, the purely spinal centres. The restraining influence of these over the muscles, pre-

*Six Lectures on Alcohol, p. 69. †Use and Abuse of Alcoholic Liquors, pp. 23-4.

vents contraction and secures their relaxation. When the spinal nerves, with which are properly included those of the medulla oblongata, are also more or less paralyzed, spasms, tetanic contractions or convulsions, will be found to be present, as sometimes occurs, in the later stages of alcoholic poisoning. § 29.

407. Indeed, Dr. Richardson, in a subsequent lecture, concedes the general principle for which we are here contending. He says,— "One of the first effects of alcohol upon the nervous system, in the way of alienation from the natural state, is shewn in the loss of memory. . . . . If this failure of mental power progresses, it is followed usually by the loss of volitional power. The muscles remain ready to act, but the mind is incapable of stirring them into action. The speech fails at first, not because the mechanism of the speech is deficient, but because the cerebral power is insufficient to call it into action. The man is reduced to the condition of a dumb animal. . . . . The failure of speech indicates the descent still deeper to that condition of general paralysis, in which all the higher faculties of the mind and will are powerless, and in which nothing remains to show the continuance of life except the parts that remain under the domination of the chain of organic or vegetative nervous matter."*

408. Practically then, as we have remarked above, and as Dr. Richardson's later statements indicate, the action of alcohol, in health, comprises two stages; one of stimulation, and the other of narcotism or paralysis. It is difficult to draw the exact line between them; for it varies greatly in different persons, and even in the same individual under different bodily conditions. As is well known, a dose which will merely produce a stimulant effect on one man, will serve to narcotize, and so to prostrate, another: and the presence of food in the stomach will also serve materially to modify or retard its full effects.

409. The habitual occurrence of the paralyzing effect of alcohol on the motor centres, is well seen, in accordance with our theory, in the permanency of the *partial release of muscular contractility from the control of the nerves*, and the consequent trembling of the hands and incertitude of action in the attempted adjustment of the muscles for operations requiring precision. This same paralyzing effect, in a certain stage of its operation on the cerebrum, and its associated ganglia, gives rise to perverted ideas, disordered mental manifestations, hallucinations of sight, hearing, and sensation. These combined effects on the sensory and motor ganglia, and on the higher cerebral mass, constitute the state known as delirium tremens; which is essentially a state of depression and not one of increased action or exalted vigor. The most successful treatment for this state, accordingly, is not of a depletive or antiphlogistic kind: but

*Lectures, pp. 111, 112.

rather one calculated to re-invigorate the enfeebled nervous ganglia and to restore the healthy nutrition of the cells on which the generation of nerve-force depends.*

Dr. Wilks regards the brain as weakened and impoverished in delirium tremens; and so closely do the symptoms sometimes resemble general paralysis of the insane, that he has twice seen it mistaken for the latter by the same physician.†

410. The first, and more active stage of this disease, however, offers an apparent exception to what has just been stated; for here, although the cranial ganglia are more or less paralyzed, yet in consequence of the previous and recent excitation of the vaso-motor nerves, during the stage of stimulation, the arteries probably remain for a time unduly distended with blood. As the secondary stage, of depression, occurs, and the propelling power of the heart is weakened by the narcotic, the blood stream becomes sluggish; thus, it not only favors the development of a higher temperature (Dr. Beale) which is in itself injurious to the tissues, but it fails to effect a sufficiently rapid metamorphosis of tissue, or to furnish an adequate supply of new material for its due nutrition. Here, then, in addition to the direct effect of the narcotic, is an indirect cause of depression, in the state of the cranial circulation, the effect of which is seen in the restlessness, sleeplessness, perversion of ideas, hallucinations, etc., before referred to.

Bromide of potassium is of use in this first stage of delirium tremens, (Dr. Ringer) because it restores the dilated vessels to their normal calibre, quickens the blood current, with the result, under these circumstances, of sweeping away the effete particles, introducing new pabulum to nourish the ganglia and hemispheres; and thus aids in restoring normal and healthy function. These effects will not follow the administration of the bromide, in anæmia of the brain; in which condition this drug is not only useless, but dangerous, and should never be administered. (Dr. Hammond.)

In a later stage of delirium tremens, or after the bromides, or other sedatives, as digitalis, cannabis indica, etc., have done their work, more direct restoratives, nutrients and food medicines, are required, and will be found beneficial.

411. Let us present this view of the case in another light. Would any intelligent physician, called upon to prescribe for the tremors of the habitual toper, say to himself, "This man's nervous system is excited. The motor ganglia are generating and discharging nerve-force towards the muscles in undue quantity, and these tremors, abnormal muscular manifestations, and incipient spasms, are the consequence. The exalted activity of these nerve centres, from which this excess of nerve-force emanates, must be lowered. My patient must be bled, purged, starved, and treated with depressing

*Dr. Aitkin, Naphey's Modern Therapeutics, p. 32. †Braith. Retros., January, 1869, pp. 49, 50.

drugs, in order to bring about this result and cure these tremors." Fortunately for humanity, the prevalent theory under which we *ought* to act would be here ignored, and instead of a debilitating, a tonic and nutritive treatment, after cutting off the poison, would be resorted to. The intelligent physician would seek to impart fresh vigor to the weakened brain, in exact accordance with the theory of these pages, and so enable the motor ganglia and nerves to control, that is to restrain, the inherent contractile power of the muscles; the partial liberation of which from nervous domination gives occasion for these tremors, just as is the case with other spasms, convulsions, or irregular muscular contractions.

412. If, in the foregoing remarks, we have not referred more fully to the authorities, in proof of the assertion that alcohol in relatively large doses is a narcotic and paralyzer, it is because the fact seemed too obvious to require confirmation. There is no lack of such proof, which the reader will find at length in Dr. Anstie's work on Stimulants and Narcotics. Dr. Carpenter says, "In the third and most profound state of intoxication there is extreme diminution or entire suspension of cerebral and sensorial power; a state of coma supervening upon that last described." *This is paralysis*, which, in Dr. Carpenter's previous stage, was only partial, but is here complete. More than once he refers in this connection to the "complete prostration of cerebral and sensorial power," and to "a total loss of sensibility and voluntary power." Again, "the functions of the cerebrum and sensory ganglia appear to be completely suspended." Sometimes the medulla oblongata and its—spinal—nerves share in the prostration. As the result, there is sometimes "difficulty of respiration, strabismus, dilated pupil, tetanic spasms, general tetanic convulsions or spasms of particular parts."*

413. Here is a problem for the admirers of the popular theory. If spasms and convulsions depend upon undue activity of the nervous centres, stimulating the muscles with an excess of nerve-force, from whence is that nerve-force derived, in view of the general and complete suspension of cerebral, sensory and motor power vouched for above?

The occurrence of these spasmodic phenomena, in paralytic states of the cranial ganglia, when their function is "completely suspended," is in exact accordance with the theory here advocated; since by motor paralysis, muscular contractile power is liberated, and exerts itself proportionably to its freedom from nerve restraint. Hence in the slighter forms of alcoholic narcosis, these spasmodic contractions are not present, because motor nerve power is not "suspended" to a sufficient degree to permit of independent muscular action.

414. An agent which produces such profound effects upon the cranial nervous system, cannot fail to injuriously impress other important tissues and organs to a greater or lesser degree. Besides

* Use and Abuse of Alcoholic Liquors, pp. 20–24.

the brain and spinal cord, the stomach, the liver, the kidneys, and the tissues generally, suffer either from nutritive changes of structure or modifications of function. This is accounted for by the fact that in health, it is simply an element in excess of the requirements of the body; and as such it is a disturber of the organic harmony, and has to be extruded as quickly as possible, either by a process of oxidation or elimination, or both.

415. As we shall see by and by—in a future chapter—the effects of alcohol in low and wasting disease, is of an entirely different character, and its *role* there is neither that of a stimulant nor a narcotic. The narcotic effect of alcohol, however, is sometimes resorted to empirically, for quasi medicinal purposes; for instance, as a reputed antidote for the bite of poisonous serpents; as a "night-cap" to excited brains, in order to induce sleep, (§ 223); as a sedative to "drown grief"; as an anæsthetic in painful states, etc. Here its effects are not unlike those of other narcotics, and are brought about in a similar manner. The sensitive, motor and vaso-motor centres and nerves are more or less paralyzed, with the characteristic effects already described, which attend this condition.

This concludes what we have to say of the narcotic effects of alcohol, and of the adaptation of our theory in explaining them. The stimulant or quasi food action of alcohol belongs to the next succeeding series of drugs, and will be considered in connection with these. (§ 459).

416. *CHLOROFORM.*—It is with the narcotic or anæsthetic effects of chloroform that we have here to deal. This result follows speedily upon the brief stage of stimulation; after which, "the whole subsequent train of symptoms is that of depression of the various portions of the nervous system, in consecutive order of occurrence; the brain being the first to lose and the medulla oblongata and sympathetic system the most tenacious in retaining their proper functions."*

417. We have already referred to the successive steps of this process in a previous page, in discussing muscular relaxation, (§ 35); and need here only recall to the reader what is stated above, that the sympathetic system usually resists the paralyzing effect of chloroform longer than the other cranial ganglia. Thus the flushing induced by the previous stage of stimulation does not fade until narcotism is well advanced, and at no time—in the normal process—is the pulse materially reduced below the ordinary rate. When this does occur, and coincident paralysis of the medulla oblongata threatens arrest of respiration, the situation is grave, and a slight further advance of narcosis and paralysis may prove fatal.

418. Coughing is among the earliest reflex effects of the first stage: but vomiting, which is not unfrequent, especially if the

* Dr. Anstie, Stim. and Narcot, p. 309.

stomach contains undigested food, never occurs until narcotism is well advanced, proving what we have before alleged, that vomiting is due to paralysis and not to stimulation of the nerves concerned.

418. Other interesting phenomena in connection with the process might be referred to, and utilized, to indicate the adaptation of our general theory to their interpretation; but the chief points have been already indicated, and it is desirable to avoid an undue expansion of these pages. The chief uses of chloroform for anæsthetic purposes, do not require any remarks from us. It is more prompt, powerful and pleasant in its action than æther; but in these very qualities lies its danger. When a fatal result is threatened, Nelaton's method of inverting the patient's body, is among the most effectual means of resuscitation. (§ 39).

For the action of chloroform as a stimulant see § 487.

419. *SULPHURIC ÆTHER.*—The general effects of this anæsthetic are similar to those of chloroform. It also has its first stage of stimulation, which is produced by small doses and is of brief duration. (See next series of drugs, where this part of its effect is discussed.)

Dr. Anstie strongly insists that those symptoms which have been ordinarily regarded as indicating excitement, such as muscular rigidity, half delirious movements, and incoherent talk—which are witnessed to a much greater degree from æther than from chloroform—are really not due to excitement proper, or indicative of true stimulation, but belong to the stage of narcosis and paralysis. He refers to cases to prove that "the symptoms referred to did not occur till the signs of advancing paralysis had developed themselves. . . . The garrulous talk was quite incoherent; the *muscular rigidity* did not appear till even a later stage, when the *symptoms of paralysis* were still more apparent, etc."* Once the stage of true stimulation "produced by doses altogether insufficient to produce paralysis of any part of the system," is past, and narcotism is begun, as shewn in the symptoms above recorded, "the whole process is essentially one; it consists, both in its early and later stages of paralysis of the various sections of the nervous system."†

420. Among the differences in æther administration compared with chloroform, one of the most striking is the flushing, vascular fulness and general signs of congestion of the head and face, accompanied by a copious flow of saliva, which attends the inhalation of æther. These effects commence with the first, or stage of stimulation, and continue and intensify till anæsthesia is complete. They are consequently coincident with the struggling and incoherent talking referred to. Dr. Anstie attributes this "flushing" to paralysis of the vaso-motor nerves of the sympathetic, permitting vascular dilatation, in accordance with the popular theory. But he states

* Dr. Anstie, Stim. and Narcot., p. 259. † Ibid, p. 285.

that it begins among the earliest signs of narcosis, while he also admits, that the sympathetic is among the last portion of the nervous centres to become impressed, towards the close of the process. Here is a palpable discrepancy as to time, which alone would invalidate his theory of the cause of flushing.

421. We have ventured to claim that in flushing and vascular fulness, the vaso-motor nerves of the sympathetic are not paralyzed, but excited, and that their function is to dilate the vessels under their control and not to contract them. (See vaso-motor chapter). On this view, the vaso-motor nerves are excited, in common with other portions of the nervous system, in the early or stimulative stage, and remain so, till as narcosis progresses, and the sympathetic is reached, they are depressed in turn. But as forming a part of the sympathetic, they are the last—in normal inhalation—to suffer depression, the vascular fulness previously set up, continues throughout the paralysis of the other centres, until their turn comes to succumb, as anæsthesia approaches completion. Then, with partial paralysis of their nerves comes contraction of the distended vessels, cessation, in part at least, of the capillary engorgement, and a more natural aspect of the features. The salivary glands, however, having their functional activity excited by the unusual supply of blood —the effect of the vascular fulness of the first, or stage of stimulation—maintain their functional activity for a time, notwithstanding the partial paralysis of the vascular dilating nerves, and only gradually return to their ordinary rate of secretive activity.

422. In those cases referred to by Dr. Anstie, where life is speedily arrested by the too rapid charging of the blood with æther, chloroform or alcohol, the sympathetic is reached—as it were—at a bound, and paralyzed almost simultaneously with the other centres. As a consequence, the vessels suddenly contract ; and the heart deprived, as by a stroke, of its proper blood supply, is unable to pulsate. Swift paralysis overtakes the medulla oblongata , respiration is speedily arrested, and the man or animal dies.

423. The flushing and congestive fullness of the face and head are much less seen in chloroform than under æther ; because chloroform is more active as an anæsthetic. It leaps, so to speak, from one nervous centre to another at a more rapid rate, and sooner reaches the sympathetic and controls it, arresting the vascular fulness of its first or early stage. This is why chloroform is more dangerous as an anæsthetic than æther, as its effects are more rapid, and it traverses more quickly the entire range of the nervous centres, paralyzing as it goes.

It will be seen how well this view serves to explain the flushing which commences with the first stage—of stimulation—and continues until the sympathetic is depressed, as the process becomes complete. The deadly pallor which marks the onset of fatal results, indicates

complete paralysis of the vaso-motor nerves, which leaves the muscular fibres of the arteries wholly unopposed, and as a consequence the calibre of the vessels is reduced and the supply of blood fails to reach the terminal vessels. In ordinary cases of anæsthesia, paralysis of these nerves is only partial, and, as a consequence, they continue to maintain a degree of dilatation of the vessels, and the pulse is not materially lessened in force during the process. This fact also serves to account for the persistence of the secretion of saliva.

424 *HYDRATE OF CHLORAL.*—The action of chloral hydrate may be compared in a general way to that of alcohol or chloroform, in that its effects vary with the quantity administered and with the condition of the patient: also in the apparent stimulation produced by relatively small doses, and paralysis by large ones.

425. Thus its first effect is to increase cerebral congestion.* In many persons it causes injection of the conjunctiva, contraction of the pupils, flushing of the face, a florid condition of the surface generally, and sometimes a rash, not unlike that of urticaria.† It is this stage of its action which increases blood pressure, and in relaxed vessels, renders it "a gentle stimulant to a feeble circulation." Here the parallelism between this drug and alcohol and chloroform, in their first or stimulant action, is well shewn. Each re-inforces vaso-motor nerve power, dilates the vascular channels, increases circulatory activity, and in this stage of their action, antidotes the effects of strychnia and that failure of nerve power on which spasm, convulsion, and similar states, have been shewn to depend.

Effects like these are obviously out of place in a group of paralyzing drugs, such as we are now considering. This portion of the action of chloral, indeed, properly belongs to the next series, which embraces the stimulants of nerve-force. It is only its narcotic qualities which entitle it to rank here; but as these are most strongly marked, and are the kind of action almost invariably sought for in its use, we have inserted it here accordingly.

426. The line of demarcation between the stage of stimulation and that of narcosis, varies greatly in different persons, and even in the same person under different bodily conditions; hence the dose of chloral—as of alcohol and chloroform—requires adjustment to the ever-varying conditions, in order to produce definite and predetermined effects. When this line is passed, by a dose, relatively sufficiently large, narcosis, with its train of opposite phenomena, begins. The nervous system is depressed. When the full effects are produced, the vaso-motor nerves are paralyzed; contraction of the muscular fibres of the arteries results—in the manner so often referred to; blood pressure in the medium trunks is increased; circulatory activity in the smaller vessels is diminished; the temperature

* Dr. W. A. Hammond, Dis. Nerv. Syst., p. 383. † Dr. Crichton Browne, Lancet, April, 1871.—"Chloral Hydrate: Its Inconveniences and Dangers."

and pulse are reduced; excitement calmed; delirium removed; fluxes, as the menses, are restrained, and sedation of the motor, sensory and vascular nerves induced. Among other effects, the brain is rendered anæmic and sleep follows.

427. If the drug be administered in such doses as to produce a further degree of nerve paralysis, and the arterial muscles are left wholly unrestrained, they contract, so as to occlude the lesser tubes, producing cold extremities, paleness, faintness, rapid, weak, labouring or irregular pulse, dilated pupils, and death from syncope, with arrest of respiration; the heart being usually found dilated and full of blood.

428. Thus the double series of phenomena produced by this drug, accord well with the theory here presented; whereas, here as elsewhere, the advocates of the popular hypothesis are obliged to attribute the vascular contraction, and consequent sedation, to excitation of the vaso-motor nerves, just as in the opposite series of phenomena, flushing and hyperæmia are attributable, on that theory, to vaso-motor paralysis. But is that theory either natural, reasonable, or physiological, which is obliged to find paralysis of one part of the nervous system, as a result of drug action, coincident with general nervous excitation and hyperæmia; and vaso-motor excitation amid motor and sensory paralysis?

For sedative purposes, chloral hydrate is often combined with bromide of potassium, digitalis, or cannabis indica: and for the relief of pain, with morphia in appropriate doses. In wakefulness and mild delirium it is a valuable hypnotic.

We have already made reference to this drug as an antidote to strychnia. (§ 112, etc.)

We think the foregoing observations on medicines of this class, may suffice for the illustration of our theory, and may serve to suggest the mode of action of other drugs of similar action, on the same principles, until the general theory on which this exposition is based is either approved or condemned.

CHAPTER XI.

DRUGS WHICH INCREASE VASO-MOTOR NERVE-FORCE, AND SO TEND TO INDUCE VASCULAR DILATATION.

429. We turn now to a class of drugs of a quality differing from the last, and which, while also acting through the agency of the nervous system, tend to increase vaso-motor nerve power, and consequently to dilate the vascular channels, in accordance with the principles already indicated.

NITRITE OF AMYL.—This is a very powerful drug, and acts with a promptness truly surprising. It does not appear to afford time for the secretion of nerve-force, and must therefore produce its effects by suddenly calling into activity the latent power of the vaso-motor centres.

A whiff or two from an uncorked phial, or the inhalation of the vapour of a few drops placed in the hand or on a handkerchief, instantly causes flushing of the face, throbbing of the arteries, and dilatation of the blood-vessels. Its action is specially exerted on the vaso-motor system of nerves, whose function we have claimed to be to antagonize the muscular tissue of the smaller arteries, and when predominant, to cause dilatation of these tubes.

430. That the action of a drug which thus excites the nervous centres and causes increased circulatory activity, has been found beneficial in spasm, tetanus and convulsion, is a further proof, in addition to those already advanced, that these states depend upon a lessened activity, and a diminished blood supply of these nervous centres, and that they are to be obviated by remedies which increase rather than diminish, vascularity and nerve-force.

Dr. Brunton first suggested the use of this remedy for angina pectoris, with a view of dilating the spasmodically contracted blood-vessels, upon which that painful disease was supposed to depend. The result has been satisfactory. Dr. Weir Mitchell, of Philadelphia, has found nitrite of amyl useful in arresting the actual paroxysm of epilepsy, though not in entirely preventing its return.* On the same theory of its action, it has been successfully used in asthma, cardialgia, tetanus, nervous headache, threatened death from chloroform, and in the collapse of cholera, where the arteries are contracted well nigh to occlusion.† It has also been successfully employed to counteract the convulsions occasioned in frogs by strychnia.

* Braith. Retros., January, 1876, pp. 243-4. † Braith. Retros., January, 1876, pp. 249, 256.

431. Dr. B. W. Richardson regards the nitrite of amyl as "the most potent known paralyzer." And yet in referring to the use of alcohol as an "anti-spasmodic," which is only another name for a stimulant, he recommends from two to five minims of the nitrite, with half an ounce of alcohol, as "an excellent combination," for the purpose referred to.* Now, the alcohol in the dose mentioned, and for the use intended, is unquestionably a stimulant. How its effect can be heightened by the administration of a pretty large dose of "the most potent paralyzer," requires explanation. We have claimed the nitrite to be a stimulant to nerve-force, and on this view the advantage of the union of two stimulants is obvious enough; but Dr. Richardson's theory is inconsistent with the fact he presents; and as the fact is doubtless true, because it corresponds with other observed facts of a similar kind, his theory must be discarded. All the facts shew that stimulants are the class of remedies most effectual in the treatment of the several diseases enumerated above, (§ 105, 119,) and as nitrite of amyl has thus proved successful, the fact tends to establish that it, too, is a stimulant.

432. It is said, when inhaled, to so influence the blood as to prevent oxygen from being given off to the tissues, for their use, so that however much oxygen the blood in the arteries may contain, it acts very much as if it were venous. In consequence of this, Dr. Arthur Gamgee found that "when the vapour of the nitrite is passed into the lungs of rabbits, they are seized with suffocative convulsions. The greater part of the blood which passed through the lungs, having been acted on by the vapour, it affects the brain just as it would have done if the trachea had been closed, and no air allowed to come near it during its passage through the pulmonary vessels, and therefore, convulsions occur as soon as it reaches the brain. Professor H. C. Wood, of Philadelphia, who has lately written a valuable paper on the action of the nitrite, found no convulsions after injecting it subcutaneously. By giving it in this way, the blood was not acted on in its passage through the lungs, and asphyxia was prevented."†

Nitrite of amyl has also the effect of "changing both arterial and venous blood to a chocolate color, due, as Dr. Arthur Gamgee shews, to the formation of nitrite oxyhæmoglobin, and by this means the ozonizing property of the blood, and hence oxydation of the tissues is lessened."‡

433. Dr. Ringer writes favourably of its use in certain irregular local flushings, or burning sensations, with perspiration, which sometimes attend the "change of life." It may be administered by the mouth, but as the effect differs greatly in different persons, less than a drop should be used at the commencement. "It may be dissolved in rectified spirit, two minims to the drachm, and of this the dose

* Addresses on Total Abstinence, 1878, pp. 31, 33. † Royal Society's Transactions,—Braith. Retros., July, 1872, p. 72. ‡ Dr. Ringer, ib., p. 313.

is three to five drops on sugar every three hours, with an additional dose as the flush begins."*

Dr. Ringer offers no explanation of this apparent illustration of the Homœopathic theory, that drugs in small doses cure symptoms and conditions similar to those they cause in large doses. His book, and the records of drugs generally, furnish numerous examples of this kind of action. The efficacy of small doses of ipecacuanha in functional vomiting, is a case in point, and others might be mentioned. On the contrary, neither nux vomica nor strychnine has proved of use in tetanus; iron in plethora; nor conium in motor paralysis; while iodide of potassium produces no effects, in any dose, which are at all to be comparable to syphilis.

Perhaps, like the hot and cold stage of ague, the "flushing" referred to has also its zero, in which a contracted state of the capillaries may be present: and as quinine cures the cold as well as the hot stage, so may nitrite of amyl cure the condition upon which the vascular contraction depends, and with that its alternative flushing.

At any rate, we are not called upon to explain every problem in "Physiological Therapeutics," and are quite content to leave some of the mysteries to future editions, or to the critics, who, of course, can readily solve them all.

434. *GLONOINE.*—This is not an officinal preparation, except among homœopathists, to whom it was first introduced by Dr. Hering, of Philadelphia, in 1850. It is the now well known and highly dangerous explosive, nitro-glycerine. It is prepared by dissolving glycerine in nitric and sulphuric acids. It is dissolved and diluted in alcohol for medicinal purposes. Like nitrite of amyl it is a prompt and powerful excitor of vaso-motor nerve action, as seen in the dilatation of the blood-vessels and the quickened action of the heart.

Dr. Richard Hughes says of it, "If you touch your tongue with a five per cent. solution, you will find that in a few minutes your pulse will have increased by from 20 to 40 beats, and your head will begin to throb and beat until a pretty violent bursting headache developes itself. With this, there will be some giddiness and a sense of constriction about the throat. If you are sensitive to the drug, nausea and faintness may supervene, and even complete insensibility ensue. This is the nearly uniform action of glonoine upon every one who has taken it."†

Dr. Hughes regards this substance as "a direct sedative upon the medulla oblongata," and interprets its mode of action as "the precise opposite" to that of hydrocyanic acid. He denies that vascular activity generally, throughout the body, is augmented, as would necessarily appear to be the case from its action on the head and heart. The drug, however, has not had that attention paid to

* Therapeutics, p. 319. † Pharmacodynamics, p. 288.

it which its remarkable physiological action would appear to deserve. It is used among homœopathists, in diluted doses, for the treatment of congestive headache, sunstroke, and the disturbance of the intercranial circulation which obtains in menopausia and sometimes in menstrual suppression.*

435. *PHOSPHORUS.*—Phosphorus is absorbed into the blood, and there acts as "a stimulant to the nervous, vascular and secreting organs. It excites the mental faculties and the sexual feelings, raises the temperature of the skin, increases the frequency of the pulse and promotes the secretions."† In large doses it is a powerful irritant and caustic, first producing inflammation of the stomach when swallowed, and subsequently of the lungs, as it reaches them in the circulation of the blood. It induces jaundice, vomiting of a substance of a dark green or black colour, and sets up fatty degeneration in all the muscular tissues.

436. Dr. Ringer writes, "For many years this substance had fallen into disuse, but owing to its signal success in neuralgia, in the hands of homœopathic practitioners, it has recently been restored to favor." Dr. Fleischmann, of Vienna, used it with marked success in pneumonia, in minute doses, and Dr. Richard Hughes says its effects are of the happiest kind in ulceration of the rectum and in chronic sinuses left in the mammary gland after extensive suppuration.‡ Administered in small and proper medicinal doses, it is regarded as exerting a special restorative effect upon the nervous tissues, and doubtless in this way is beneficial in neuralgia and other diseases of exhausted vitality. Its "food action" is shewn in improved appetite, increased rate of circulation, a heightened temperature, increased perspiration, abundant urine, a sharpening of the mental faculties, etc. (Ringer.) Dr. Hammond praises it in cerebral softening and hysterical paralysis; Dr. Anstie in chronic alcoholism, and Dr. Thompson recommends it strongly in megraine. It is often serviceable in angina pectoris, a disease which is closely allied to, if it be not a true neuralgia. (Ibid.)

437. The medicinal use of phosphorus is a strong proof of the truth of our theory of vaso-motor innervation. For it is admitted that it increases nerve-force, and at the same time produces vascular fullness and congestion. Nerve-force, then, *dilates* the arteries; whereas, on the accepted theory, the arteries are dilated only in proportion as nerve-force is paralyzed, and to excite nervous agency is to cause vascular contraction. Here, then, is a drug acting palpably in antagonism to the popular theory; a fact which we leave to the advocates of that theory to explain.

438. *AMMONIA.*—The preparations of ammonia, as used medicinally, are mild stimulants, which through their action on the vaso-

* Hughes, p. 289, etc. † Dr. Pereira, Mat. Med., Vol. I., p. 257. ‡ Pharmacodynamics, pp. 439, 449.

motor nervous system, assist in maintaining the circulation, and partly in this way and partly by a direct action on the secreting follicles and glands, increase the secretions generally. Dr. Headland states that "ammonia has been used with advantage in the prevention of epileptic fits,"* another proof of the theory here advocated. As a stimulant, however, its action is transitory, and it is much inferior to dilute alcohol.

The carbonate of ammonia is occasionally administered in low fevers and asthenic inflammations of the respiratory organs, chiefly for the purpose of sustaining the circulation.

The solution of the acetate of ammonia serves the purpose chiefly of a mild diluent, and as such is prescribed *ad libitum*, in combination with diaphoretics or diuretics.

The muriate, or chloride of ammonium, is a very valuable drug. Under its use the tongue is cleaned, the secretions increased, expectoration rendered easier, and elimination of effete products facilitated. It is of much service in relieving inflammatory face-ache, intercostal and muscular pain, the megraine consecutive to profuse menstruation, neuralgia of the uterus and other organs.

These beneficial results of the drug are doubtless attributable to its action in improving circulatory and nutritive activity in the suffering parts, as well as to the general "alterative" action it exerts. Among its other uses, it sometimes aids in restoring the menses.

It is said that a full dose of spirits of ammonia will often speedily steady and sober a drunkard. Dr. Pereira speaks highly of its use "in poisoning by those cerebro-spinants commonly termed sedatives," from which it would appear that this antidotal action of ammonia is exerted through the nervous system. Liquor ammonia is useful in neutralizing the effects of formic acid, which constitutes the poisonous principle of the stings of wasps, bees, and other insects.

439. *TURPENTINE.*—This drug, in small doses, of five to ten minims, is a stimulant. In very large doses, half an ounce to an ounce, when not speedily extruded from the system by purging and diuresis, it produces a species of intoxication, shewing it to possess narcotic powers. Its effects on the vaso-motor nerves are similar to other medicines of this class, and its action over the circulatory system accords with our theory.

It is inadmissible in acute sthenic fever; but in atonic or adynamic states, depending on the poison of typhus or puerperal fever, in tympanitic distention of the abdomen, from accumulated flatus, it is prescribed with much advantage.

The student will do well to remember that in typhoid states, when the coating of the tongue peels off irregularly, or when the

*Action of Med., p. 269.

surface of that organ is dry and glazed, this drug will be found specially indicated. An emulsion is a convenient and agreeable form for its administration. As an enema in tympanitis, it may be mixed with the white of a raw egg, and repeated according to circumstances.

Besides the mode of action referred to above, on the nervous system, turpentine doubtless also exerts an influence directly on the blood, on the mucous surfaces, and on the glands, through which it is eliminated, and is prone to set up irritation of these structures, in this process, when too freely administered.

440. *GUIACUM.*—This is another remedy of this class, and to some extent exerts a stimulating effect over the vascular system, combined with an "alterative" influence over the secreting organs. It is sometimes used with advantage in chronic rheumatism, gout, dysmenorrhœa, etc. The ammoniated tincture is the most active preparation of this drug, combining, as it does, the stimulating qualities of both ammonia and guiacum.

441. *SULPHUR.*—This useful but neglected remedy belongs to the class we are now considering. Dr. Pereira says of it, "In small and repeated doses it acts as a gentle stimulant to the secreting organs, especially to the skin and the mucous membranes, particularly the bronchial membrane. It promotes the capillary circulation of these parts and increases their secretion."* Dr. Richard Hughes says it produces a "decided determination of blood to the head," sometimes causing vertigo.† Here, again, we have a stimulant producing increased vascular activity. How is this brought about if vascular fullness depends on vaso-motor paralysis? The position is very clearly understood if vaso-motor nerve-force *dilates* the arteries, and a mild stimulant assists them in doing so. That is what we claim for it, in antagonism to the popular theory.

Besides a gentle stimulation of the nervous system, sulphur produces effects also on the blood and tissues; on the mucous membranes and skin, which are well known, or the facts in relation to which are easily accessible to every reader.

442. *COLCHICUM.*—Dr. Ringer says "the physiological effects of colchicum are very similar to those of veratrum, yet one cannot be therapeutically substituted for the other." It is a vascular depressant, but while "it will abolish gouty inflammation as if by magic, it exerts scarcely any influence in other inflammations." (Ibid). Gout is believed to depend chiefly upon an excess of uric acid or urate of soda in the blood, (Dr. Garrod). Colchicum cures gout, but "exerts no influence on the elimination of uric acid in gouty people." (Ringer). It causes notable purging, but its curative effects on gout are said to be best displayed when purging does not accompany its administration.

* Mat. Med., Vol. I, p. 356. †Pharmacodynamics, p. 515.

443. Dr. Wilkes confirms the interesting fact, observed by Dr. Garrod and others, that lead poisoning produces gout, "and apparently true gout, since the arthritic inflammation is due to the deposit of urate of soda in the joints;" and is attended by the usual concomitants of gout. Dr. Wilkes, after calling attention to the causes of gout, such as mal-assimilation of food, excess of nitrogenous food, wines, etc., asks, in what way lead poisoning so affects the digestive and assimilative processes as to favor the production of urate of soda? He says, "This, we believe, is the question to be asked, and not a simple chemical one, because we find attacks of gout caused by disturbances of the nervous system, and relieved by such remedies as quinine, mineral acids and colchicum; causes and remedies which can only indirectly affect the functions before named, and do not act by simple chemical methods.*

444. This view of gout points to the nervous system, as the portion of the organism chiefly concerned in its cause and cure. What, then, are the effects of colchicum on the nervous system? The profound prostration and general muscular weakness caused by excessive doses, seem to point to depression of the motor nerves. If pain be a form of sensory paralysis, as Dr. C. Handfield Jones,† Dr. Radcliffe, Dr. Anstie, and others believe, then the sensory nerves are also depressed, for colchicum causes severe pains in the extremities and head. The vaso-motor system is also more or less paralyzed, and, as a consequence, the arteries are abnormally contracted, as is seen in the weak and intermittent pulse, pinched features, and cold extremities.

445. But there are also evidences of tissue irritation, shewn by congestion and ecchymoses in the stomach, intestines, lungs, heart, diaphragm, etc. In this, the intestines are the part of the organism which, if not always the most inflamed, appear to be the most actively disturbed, since even when injected into a vein, it is through the glandulæ and follicles of this canal that the poison is chiefly eliminated. This task the kidneys appear only to share in a secondary degree; since the urine, though usually rendered hot and painful, is not as a rule materially increased. The salivary glands display considerable functional activity.

Colchicum, then, in large doses, would appear to be a general nervous sedative, and at the same time an active tissue irritant. Perhaps the latter quality may furnish a reason why its sedative action does not assist in the cure of other and ordinary inflammatory attacks; the irritation set up in some organs proving too strong for the vascular sedation accompanying it.

446. The effects recounted above, however, are the result of doses more or less poisonous; and like some other drugs of this class, the effects of small or moderate doses may be of a different or opposite

* Brit. Med. Jour., 1875, p. 10. Braithwaite's Retros., July, 1875, p. 49. † Braith. Retros., July, 1876, p. 20.

kind to that of large ones. Thus, Dr. Austin Meldon, (Dublin) has found by experiments on himself, that ten or fifteen minims of the tincture of colchicum seeds produced "increased action of all the organs of the body; the skin became moist; the action of the kidneys and liver increased; the mental faculties invigorated and the heart's action accelerated so as to cause palpitation. All these results," he says, "can only be produced by a nervous stimulant."*

Dr. Meldon says, "In Ireland gout is one of the rarest affections met with in hospital practice, yet I have repeatedly found the blood, in otherwise healthy men, lying in our accident ward, loaded with urates, and my own blood has been in this condition for years, although I have never had the least symptoms of gout. Dr. Gairdner found urates in the blood of a boy four years of age, in whose family gout had never been known."† From this he infers that the presence of urate of soda cannot be the sole cause of this distressing malady. His theory is that the uric acid and soda are kept in a separate and fluid state, a condition in which they may be eliminated, so long as nerve-force is normal and active; but when nerve-force is depressed, "these two substances unite in the tissues most removed from the centre of the circulation." Irritation and inflammation are then set up, and "excite the nervous system to increased energy and the disease is for a time arrested." Colchicum, as a nervous stimulant, assists and shortens the process.

Dr. Meldon thinks that the onset of the paroxysms at night, when nerve-force and circulatory activity are weakest; and the seat of the disease, the great toe, favour this theory. If this view were correct, then nerve tonics or stimulants ought also to prove beneficial in gout; and accordingly, he points out sulphate of nickel and the triple phosphate of iron, strychnia, and quinine, as remedies from which he has derived most benefit.‡

Dr. Rees, of Guy's Hospital, thinks "the phenomena of the acute gouty paroxysm are best explained on the theory that the disease is essentially a capillary phlebitis; the venous inflammation being caused by the circulation of a blood poison."‖

Dr. Gairdner differs materially from Dr. Garrod in regard to the pathology of gout; and insists that if the painful symptoms are owing to the deposition of urate of soda, the pain should occur coincidentally with it: whereas the pain and vascular excitement occur before the swelling, and subside on its appearing.§

It is impossible, at present, to reconcile these conflicting views, and we submit them to the reader as we find them. Colchicum, in some way, relieves the pain of gout; but is better adapted for the strong and vigorous than for the weak and asthenic. It does not prevent a return of the disease, and is even thought by some to favour its recurrence. Hence it is more palliative than curative.

*Lancet, 1872, p. 114. Braith. Retros., January, 1873, p. 46. †Ibid. ‡Ibid.
‖Braith. Retros., July, 1877, p. 42. §Ibid.

It has no proper anodyne properties and amid its marked general disturbance, it leaves the cerebrum and the mental faculties comparatively unaffected.

448. *ARSENIC.*—This is a remarkable drug. Its action upon several distinct parts of the organism is worthy of special study. We will glance at these effects separately.

1st. Arsenic, by one mode of its poisonous action, paralyzes the sensory and motor ganglia of the brain and motor nerves. This result is seen in that mode of death from its use, in which profound coma, from which the victim never wakes, sets in early, without the occurrence of the usual intestinal inflammation.* This state of coma depends primarily, and perhaps solely, upon a suspension of the functions of the ganglia mentioned.†

The paralyzing action of arsenic on the motor centres or nerves is seen in a less degree in the chorea-like restlessness, trembling, twitching, cramps or convulsions which constitute ordinary phenomena in arsenic poisoning. Hahnemann long ago pointed out the "constricting power of arsenic," over muscular tissue, as shewn in the extremely contracted states of the cardiac and pyloric orifices of the stomach and of the sphincters and ducts generally, as well as of the voluntary muscles. Dr. Richard Hughes, recounting these effects, remarks that "they can hardly be produced through the motor nerves, as these are more or less paralyzed." Precisely, and that very paralysis, as we have heretofore shewn, is the necessary condition under which these spasms and contractions invariably occur.

Nor is it the musculo-motor nerves alone which are paralyzed. The vaso-motor nerves, which dilate the blood-vessels, also partake of a similar depression: and, as a consequence, we find an effect sometimes produced on the circulatory channels not unlike that of aconite, as seen in coldness, faintness, collapse, etc.‡

449. 2nd. Arsenic is also a tissue irritant, and, in other than the comatose cases, produces inflammation of a corrosive or ulcerative kind throughout the whole mucous tract of the alimentary canal, constituting a gastro-enteritis of a most painful and fatal kind. Nor are its effects confined to the mucous tissue. The serous membranes, the skin and the large viscera are also involved in its action, though to a lesser degree. Hence the effusions, petechial eruptions and ecchymoses witnessed after death from arsenical poisoning.

450. Are these degenerative changes in tissue, which in the liver, kidney, heart, etc., are said to assume the fatty kind, the effects of this poison on the nervous centres, transmitted from thence to the viscera and surfaces of the body; or are they the effect simply of an irritant action exerted directly upon the tissues themselves?

*Dr. Ringer, Therapeutics, p. 225. †Dr. Carpenter's Physiol., p. 840. ‡Dr. Pereira, Vol. I., p. 632. Dr. R. Hughes, Pharmaco., p. 108.

Some support is given to the former view, by the well known fact that disease of the nervous centres is not unfrequently attended by degenerative changes in distant parts, as acute sloughing in the sacral region, in spite of every precaution, the appearance of bullæ on the skin; internal congestions and extravasations, inflammations of joints, muscular atrophy, etc.*

The general diffusion throughout the body of degenerative changes in arsenical poisoning, and the peculiar character of the burning pains, which are also characteristic of pains in parts suffering from mal-nutrition, or after nerve wounds, would also seem to favour the supposition that the peripheral effects of arsenic were secondary and incidental to the primary lesion of the nervous centres: especially as these peripheral effects seem to be the alternative, or to take the place of fatal effects on the central ganglia. Another circumstance favorable to this view is to be found in the fact that the effects of arsenic usually shew themselves most in one side of the body; as is the case also with cranial lesions, with which, in addition to the distant degenerative changes mentioned, hemiplegia is not unfrequently associated.

451. From the two chief modes of action of this drug, just mentioned, it is no way surprising that its effects, in somewhat less than poisonous doses, should be those of a profoundly adynamic kind, and that wasting and prostration should be among its characteristic effects in hurtful doses. These references to the poisonous effects of arsenic are not only interesting as items of knowledge, but useful, because they furnish a clue to the class of cases in which this drug displays its curative powers in nutritive doses.

452. In such diseases as coryza, influenza and asthma, where motor nerve-force is impaired, the nutritive qualities of arsenic are often highly useful, particularly where a degree of periodicity in the return of the paroxysms is present.

In ulcer or corrosion of the stomach, in marasmus and chronic diarrhœa, with organic changes of structure in the intestinal tube, characterized by putrid, ichorous or shreddy semi-membranous excreta, arsenic is invaluable. In low fever, with extreme prostration, it will frequently be prescribed with advantage. The vomiting which arsenic controls is not the simple functional vomiting for the cure of which ipecacuanha is famous, but rather that from ulcerous or cancerous erosions of the gastric mucous membrane.

In skin diseases arsenic has won a high reputation. It is indicated in that harsh, dry, branny condition of the surface we sometimes see, as well as in many of the more moist and vesicular eruptions; and in the puffy œdematous condition of the cellular tissue, often first seen in the eyelids.

Cancer, warts, and other malignant or non-malignant growths are destroyed by arsenic, either pure or mixed with some bland powder,

*Dr. C. H. Bastian, Paral. from Brain Disease, pp. 163, 169.

as starch. What is here necessary to do is to bring the poison in contact with the raw surface, and then to excite inflammatory action, speedily and completely, as thereby the tumor is destroyed, and absorption of arsenic prevented.*

In the treatment of ague, arsenic is far inferior to quinine, where the periodicity of the stages are well marked and of regular occurrence; but where the typical periodicity is less marked, and the coldness and heat alternate irregularly and more frequently, while their respective duration is shorter, arsenic is usually preferable.

How these and some other drugs antidote this state is unknown. If such a thing as malaria exists and influences the system through the agency of poisonous germs, their antidotal qualities as antiseptics, destroying these germs, might be quoted. But as grave doubts have been thrown upon the existence of such a thing as malaria,† and since the effects attributed to it have been referred to sudden changes of temperature, which shallow or marshy bodies of water favor by free evaporation during the day, and condensation at night; we may after all be compelled to attribute the curative effects of these drugs to their special nutritive effects on nerve tissue, and probably also on blood plasma.

453. We have been led into remarks of this length rather from the interesting character of this drug than from its intimate connection with our general subject. Arsenic in poisonous doses, is, then, a sedative and paralyzer, and also a tissue irritant. Its true medicinal action in small doses, points to its association with other drugs which act as stimulants to nerve function, and among these we place it accordingly.

454. *QUININE SULPHATE.*—See last series of drugs, (p. 182) and former remarks. (§ 186, 236, 371.)

455. *STRYCHNIA.*—The "food-action" of this drug should naturally find a place here; but it has already been considered in connection with our general argument. (§107, 237, 363.)

456. *JABORANDI.*—This is the Indian name of the plant pilocarpus pennatifolius. Its active principle is a powerful stimulant, especially to the functions of the skin and salivary glands, the secretions of which it increases in a remarkable degree.

Jaborandi is evidently a stimulant to the nervous system; and like other members of its class, the flushing it produces is, after a certain dose, followed by pallor and some degree of prostration, indicating that besides its stimulating qualities, it also possesses narcotic properties. As a stimulant it excites the vaso-motor, as well as other nerves, quickens the heart, restores regularity where the pulse is intermittent, dilates the arteries, causes increased flow of blood to the brain,—as seen in the contraction of the pupils,—

*Dr. Ringer. p. 216. †Dr. T. Inman, Brit. Med. Jour., 1875, p. 172. Braith. Retros., July, 1875, p. 18.

augmented blood supply to the capillaries of the skin and to the glands generally. Hence the effects on these organs referred to above, in addition to which is the notable increase in the secretion of milk in nursing women.

457. The drug is a comparatively new one, and experience is wanted to fully test its powers; but it really appears that whenever a powerful sialagogue, galactagogue, or diaphoretic is needed, jaborandi promises to supply the want much more promptly and effectually than any of our older drugs. Much additional light will yet be thrown upon its effects and uses. Dr. Laycock has used it with advantage in diabetes, both forms of which together with certain kinds of Bright's disease he regards as *neuroses*; and recognizes the action of jaborandi as taking place through nervous agency.*

458. Jaborandi is a powerful rival and antagonist to belladonna; and produces effects on the nervous, and through this on the vascular and secretory systems of quite an opposite kind to that drug, as a comparison of their respective effects will readily shew.

459. *ALCOHOL*, (as a stimulant).—We have already dealt with the narcotic, depressant, or paralytic action of alcohol in large doses, as among the phenomena belonging to the former series of drugs. We have here to consider that first stage of its action in which it is truly a stimulant; conduces to the activity of nerve-force; and sustains the organism as a food medicine, in states of feebleness and exhaustion.

460. A great deal of controversy has taken place in reference to the true action of alcohol in the body; a review of which alone would fill a moderately sized volume. It is admitted, however, by all the authorities, that persons in health, whose mental and bodily functions are normally performed, do not require, and are far better without alcohol in any form. The latest experiments of Drs. Anstie and Dupre appear to have proved conclusively, and to the general satisfaction—in opposition to those of Lallemand and Perrin—that of the alcohol taken into the system, up to a certain quantity, only a mere fraction is eliminated as alcohol, through any of the emunctories, and almost the whole is utilized in some way, in the vital chemistry of the body. When taken in quantities greater than can be thus utilized, the excess is carried off in the excretions.

There is still much difference of opinion as to the manner in which alcohol is disposed of in the body, and of the way in which it exerts its undoubted beneficial effects in certain diseases.

461. The following quotation, from Dr. T. Lander Brunton, F.R.S., of St. Bartholomew's Hospital, London, embodies the views of the great majority of physiological writers and teachers on this subject:—"The importance of the question, whether alcohol undergoes oxydation in the body or not, consists in this: if it is oxydized it will supply energy for muscular exertion, or for keeping up the

* Lancet, 1875, p. 242. Quoted in Braith. Retros., January, 1876, p. 80-83.

animal heat, or for both, and will therefore be entitled to rank as food, while if it is excreted unchanged, it will have no claim to the name, and must be classed with such substances as the organic alkaloids, which after acting on the nervous and muscular systems, while they are circulating in the blood, pass out after a while by the emunctories. It is the merit of Baudot, Anstie and others, who have worked at this subject, to have shown that *alcohol is oxydized, and is thus to be reckoned as a food and not merely as a drug.* But still more satisfactory evidence of its claim to the title of food is afforded by the fact that it will keep up the weight of the body and prolong life when the supply of other food is insufficient or is entirely wanting."

"Dr. Hammond found that when he took an insufficient diet, and was daily losing weight, the addition of alcohol not only prevented this loss of weight, but converted it into an actual gain. In his work on "Stimulants and Narcotics," Dr. Anstie has collected a number of cases in which persons have lived for a considerable time upon it alone, or along with a quantity of food so small as to have been utterly inadequate without it."

"From a survey of all the evidence on this subject, I think we may conclude that in moderate doses, alcohol undergoes combustion in the body, and will supply energy, yield warmth, and tend to sustain life, in the same way that sugar would do, and is therefore to be reckoned as a food. At the same time it has a power of diminishing oxydation, which prevents its employment as food to any great extent in health, but greatly increases its utility in disease."

"In feverish conditions it diminishes tissue waste and thus keeps up strength in three ways:—1. It undergoes combustion itself as a food, instead of the tissues. 2. It lessens oxydation in them. 3. It lowers the temperature which itself increases tissue degeneration. It may perhaps seem rather contradictory to say that it undergoes combustion and yet diminishes combustion; but in this respect we may compare it to the sulphur which some people are accustomed to throw into their grate, when the chimney takes fire, the sulphur burns but it puts out the blazing soot." . . . . "If alcohol always quickened the pulse in disease, as it generally does in health, it would probably be injurious in prolonged illness, as it was found to be in prolonged exertions by the soldiers in Ashanti. But this is not the case, for in fever the quick pulse frequently becomes slower after the administration of alcohol; and, indeed, an excellent rule of practice is not to give alcohol if it increases the rapidity of the pulse already too quick. Alcohol thus economizes the vital power of the heart, and tends to prevent death from exhaustion."

Dr. Brunton enumerates the following as the chief points of his paper:—

"1. Alcohol in small quantities, increases the secretion of gastric

juice, and the movements of the stomach, and thus aids digestion. Although unnecessary in health, it is useful in exhaustion and debility.

"2. It increases the force and frequency of the pulse, by acting reflexly through the nerves of the stomach.

"3. In large doses it impairs digestion by over-irritating the stomach.

"4. It may produce death reflexly, by shock.

"5. After absorption into the blood it lessens the oxydizing power of the red blood corpuscles. This property renders it useful in reducing temperature; when constantly or very frequently present in the blood, it causes accumulation of fat, and fatty degeneration of the organs.

"6. It undergoes combustion in the body, maintains or increases the body weight, and prolongs life on an insufficient diet. It is therefore entitled to be reckoned as a food.

"7. If large doses are taken, part of it is excreted unchanged.

"8. It dilates the blood-vessels, increases the force and frequency of the heart, by its action on the nervous centres, to which it is conveyed by the blood, imparts a feeling of comfort, and facilitates bodily and mental labour. It does not give additional strength, but merely enables a man to draw upon his reserve energy. It may thus give assistance in a single effort, but not in prolonged exertions. [The last sentences apply to its use in health and not in disease.]

"9. The same is the case with the heart; but in disease alcohol frequently slows, instead of quickening, the pulsations of this organ, and thus economizes instead of expending its reserve energy.

"10. By dilating the vessels of the skin, alcohol warms the surface at the expense of the internal organs. It is thus injurious when taken during exposure to cold, but beneficial when taken after the exposure is over, as it tends to prevent congestion of internal organs.

"11. The symptoms of intoxication are due to paralysis of the nervous system, the cerebrum and cerebellum being first affected, then the cord, and lastly the medulla oblongata. It is through paralysis of the medulla that alcohol usually causes death.

"12. The apparent immunity which drunken men enjoy from the usual effects of serious accidents, is due to paralysis of the nervous mechanism, through which shock would be produced in a sober condition."*

462. The foregoing is not a merely individual or isolated opinion; but is held by all but a mere fractional part of the profession. The only dissentients of note, to the opinion which asserts the food action of alcohol, so far as we have been able to learn, are Dr. B. W.

* Practitioner, 1876, p. 121.—Braith. Retros., July, 1876, p. 232.

Richardson, F.R.S., and Dr. Lionel S. Beale, F.R.S. The former bases his argument on the admitted fact, that alcohol does not contain the materials from which the tissues of the body are nourished or built up. Taking his stand on the purely chemical facts of the case, he insists "that alcohol cannot by any ingenuity of excuse for it, be classified among the foods of man."* He admits, however, that alcohol is "decomposed in the body," and "is transmutable into new compounds," and not eliminated unchanged, and also that "by some unknown process it may be transferable into fat."†

As a matter of fact, on the subject of vital chemical changes, very little is yet definitely settled; and an appeal of this kind, on purely theoretic grounds, will not suffice against the well authenticated facts of practical experience, which Dr. Richardson seems to have systematically ignored, or which, at all events, he makes no effort to explain.

463. Dr. Beale fully recognizes the value of alcohol as a remedy in febrile and other exhausting diseases; but he denies its food action. What it does, he claims, is to restrain the undue growth of bioplasm, with which the blood-vessels are loaded, the circulation retarded, and the temperature increased in fever. It does this, if not by actually coagulating the surfaces of these minute masses of albumenoid germinal matter, at least by condensing their substance and rendering them less permeable, and so less accessible to the nutrient fluid surrounding them. Alcohol, he intimates, also lessens the calibre of the vessels, through an influence exerted on their vaso-motor nerves, and so condenses their walls as to lessen the exudation through them of these amæboid particles. Dr. Beale differs from his contemporaries in holding that there is deficient oxydation in the febrile state, the effect of which is, that quasi nutrient materials which ought to be eliminated, as urea, uric acid, etc., are retained in the blood, and furnish pabulum in undue quantities for its bioplasm, which consequently not only grows and multiplies in the vessels, but that passing through these—as in pneumonia—the neighboring tissues become the seat of active proliferation and excessive cell growth. Fever and inflammation, he holds, are essentially the same process, in one case general and in the other local: the condition he describes is applicable to both. Alcohol, by its alleged action, reduces the rate of growth of the rapidly increasing bioplasm, and in so doing reduces the temperature, favors a slower and more healthy cell growth, and promotes a return to normal nutrition. Besides, by maintaining the force of the heart's action, and thereby "promoting free circulation, so as to keep the whole mass of the blood moving and mingling and changing, not only is the growth of its bioplasm impeded, but the bioplasm already formed is exposed to oxydation and other changes, which lead to its disintegration, to be soon followed by the removal of the pro-

* Six Lectures on Alcohol, p. 73. † Ibid., pp. 62, 68.

ducts of its decay." A favorable effect is thus exerted on the temperature, which increases as the circulation becomes more feeble. Dr. Beale believes that in this way "we may explain the beneficial action of alcohol, without assuming that it is a food, or contributes directly to the ordinary process of nutrition.*

464. Dr. Anstie objects to this view of the case, on the ground that the alcohol in the blood is much too dilute to produce the effects attributed to it; and also, because it does not serve to explain "how alcohol calms delirium and promotes natural sleep, in a manner not distinguishable from that in which ordinary food as meat and soup acts."† And certainly Dr. Beale, in the work from which we have quoted, is extremely reticent as to the manner in which alcohol produces sedation.

Here, as elsewhere, the weight of authority must determine conclusions; and as we have already stated, the great mass of medical authority pronounces alcohol to be in a certain sense a food; not in health, but in certain states of disease attended with exhaustion.

465. As regards the effects of alcohol on the temperature of the body, Dr. Richardson, from experiments conducted by himself, finds that in the first stage, that of stimulation, alcohol increases the external temperature of the body in man, from half a degree to a degree and a half; but at the same time he claims that the internal heat is lessened. During the subsequent stage of narcotism, he finds the temperature increasingly reduced in man often as much as two or three degrees. The greatest decline occurs in alcoholic coma, and of course indicates danger to life. This condition is distinguishable from apoplexy owing to the fact that in the latter disease, the temperature, instead of being lowered, is above the normal standard of 98° Fahrenheit's scale.‡

In proportion to the decline of temperature, Dr. Richardson finds "a decrease in the amount of the natural product of combustion in the body," notably carbonic acid; the inference he draws from which is, "that the alcohol is not burned after the manner of food which supports animal combustion; but that it is decomposed into secondary products by oxydation, at the expense of the oxygen which ought to be applied for the natural heating of the body:" and as a consequence that it is useless as an agent for maintaining the heat of the body.‖

466. Dr. C. Binz, Professor at the University of Bonn, replies as follows to the foregoing views. After quoting the above from Dr. Richardson, he says:—

"It seems to me that the inference so drawn, however plausible in theory, is overborne by the following facts elicited from experiments. First, that after *small* doses of alcohol, neither the temperature of the blood, nor the quantity of urea in process of being

* Disease Germs, pp. 328, 420, 423, etc. † Stim. and Narcot., pp. 238, 380, 384.
‡ Lectures on Alcohol, p. 70. ‖ Ibid, pp. 71, 72, 73.

thrown off, is found to be measurably diminished. Secondly, that even such quantities as lowered the temperature of the blood at first, cease to produce this effect after having been repeated a few times. Thirdly, that when there is no impediment to the respiration, the organism obtains much more oxygen than it can consume. Fourthly, that no 'secondary' product of alcohol has been found as yet in the organism."

The Editor of Braithwaite's Retrospect, says "the observations of Dr. Binz are peculiarly valuable upon this subject, as they are based upon his own experimental researches." We therefore quote him further on the question of temperature. He says:—"I have convinced myself by a series of experiments that alcohol is completely destroyed in the animal organism. . . . . The facts observed all seem to lead to the conclusion that alcohol in the body, just as in the flame of the spirit lamp, is oxydized to carbonic acid and water. Such being the case, it is evident that every molecule of alcohol burned within the system must yield not only warmth but that power to accomplish work with which the development of caloric is always accompanied."

Dr. Binz then proceeds to compare the relative heating power of alcohol, pure coal, hydrogen, and cod-liver oil, which stand to each other as 7, 8, 34.5, and 9.1, respectively. Four tablespoonfuls of cod-liver oil—about fifty grammes—are equal to sixty-five grammes of alcohol, for the purposes of producing heat. He continues:—"The advantages possessed by the latter over the oil are obvious. Besides being infinitely more pleasant to take, the alcohol, if largely diluted with water, in the form of good wine, is readily digested, even in the weakest stomach; and as has been shewn, is easily and completely disintegrated in its passage through the system. On the other hand all fatty substances require for their emulsion, absorption and assimilation, a very considerable amount of work, which of course is only that much more drain upon the powers of the patient."

We pass over the testimony of Dr. Binz as to the value of a continual supply of wine in enabling the patient to resist for a length of time the ravages of severe disease, where no other form of nourishment is accepted by the stomach. Typhoid fever and the earlier stages of pulmonary tuberculosis are especially referred to in this connection. A good deal of importance is attached to the purity of the alcoholic fluid, and also to the manner of its administration, which he appears to intimate should be in moderate and repeated doses. In this way "it will not affect the temperature of the body to any measurable extent: it will simply burn, as will any other innocent digestible hydro-carbon, giving off its proper quantity of heat to the tissues, and resolving itself into carbonic acid and water."

"To produce an antipyretic effect, an adult will require a dose of

about two fluid ounces of absolute alcohol. . . . . Where the digestion is healthy, and where a sufficient transfer of nutritive material takes place from the food to the blood, the human body is capable of accomplishing all the functions for which it is designed, without the use of spirituous drinks, which in health are entirely superfluous."

Dr. Binz sums up his views as follows. "1st. That alcohol is very frequently a stimulant of transitory power. 2nd. That in relatively large doses it can serve as a vigorous antipyretic. 3rd. Alcohol given in small and oft repeated doses is a food particularly adapted to cases where the stomach can take no other 'combustible material' to supply warmth and working energy to the organism."*

Other observers—Dr. Parkes, Dr. Ringer, Dr. Rickards—find that while alcohol in two-ounce doses, given to a healthy fasting man, reduces the temperature, this result does not follow if given with food, even to the extent of four to eight ounces. Nor is a reduction in the temperature readily produced in those habituated to its use, as was shewn in the administration of twelve ounces of good brandy to an habitual drunkard, making him "dead drunk" without the smallest reduction of the temperature.†

468. From the foregoing it will be seen how wide is the difference between the views of Dr. Richardson as to the sustaining and heating qualities of alcohol, and those of other observers, numbers of which might be quoted, equally capable and sincere as he. Leaving the food question out of sight for the moment, we find that all agree that alcohol in moderate doses, produces temporary stimulation, with increased vascular and functional activity: and that in large doses—varying with the habits and temperament of the patient—it produces sedative, depressing or paralyzing effects on the nervous system, with reduction of temperature as a rule.

469. The question may reasonably be asked, if the first of these effects are produced by the combustion of alcohol, and the consequent liberation of heat and force in the body, why should not the same process be continued and even intensified, instead of being partially arrested, by the larger quantity? The theory of these pages supplies the answer. The small dose increases nervous activity, dilates the arteries, quickens the pulse, increases vascular activity generally, and so favors those changes in the minute vessels and capillaries, where the effete matter is exchanged for new, where the carbon of the tissues meets the oxygen to produce combustion, for this process is going on all over the body in the vascular ramifications as well as in the lungs, and hence the increase of temperature.

470. On the contrary, the narcotic dose of alcohol, as we have seen in our former reference to this drug, paralyzes not only the

* Practitioner, May, 1876. Braith. Retros., January, 1877, p. 30. † Dr. Ringer's Therapeutics, p. 276.

sensory and motor, but the vaso-motor ganglia or centres. Paralysis of the latter, as so often indicated in these pages, puts an end to vaso-motor, dilating, force, sets free the inherent contractile power of the muscular coat of the arterial vessels, which contracts accordingly; thus reducing the calibre of the arteries, lessening vascular activity, and so diminishing, or in extreme cases arresting, the interchange of gases and elements just referred to, on which the process of combustion and calorification essentially depends. A decline in the temperature of the body necessarily follows.

471. This explains why it is that when food is taken with the narcotic, it not only retards its action, by delaying absorption, but the stimulus of food on the nervous sytem, to some extent, antidotes the depressing effect of the alcohol, and accordingly, as stated by Dr. Ringer, the temperature is little if at all reduced. Again, in the habitual toper, in whom the reduction in temperature sometimes fails to occur, even from narcotic doses, whose vascular nerves are subjected to frequent stimuli, the blood-vessels may be assumed to be perpetually dilated. The muscular fibres of their walls are doubtless enfeebled, so that when liberated by the paralysis of their nerves, they contract slowly or imperfectly, and thus fail, for a time, materially to diminish capillary fulness, or to arrest the process of combustion going on within them.

Thus the theory we advocate, we think, furnishes a reasonable exposition of the double effect of alcohol, as administered in small or large doses. There are times and conditions in most men's lives when the first or stimulant action of this drug is found grateful and beneficial. It is doubtful if this can ever be said of the resort to narcotism from alcohol.

472. It is necessary especially to note that in the use of alcohol in low and wasting diseases, even when comparatively large doses are resorted to, the effect sought and produced is neither "stimulation," in the sense of excitement, nor narcotism. There is thus a great difference in the effects of alcohol in health and disease, which must not be overlooked. In perfect health, alcohol, in a stimulating dose, is something super-added to the needs of the organism, in excess of what is really required, and is hence injurious. In narcotic doses, it is a poison, and as such is a disturbing cause until it is decomposed, or eliminated. In disease there is *a want* in the system, which alcohol supplies, just as arsenic, strychnia, or quinine, respectively supply certain deficiencies of different kinds in corresponding states of the system. In exhausted conditions of the body, this want is so comparatively great, that relatively large doses of this quasi food are required to supply it: and its effects in such conditions are similar to those of other foods, when these can be digested. That is, it retards the waste of the body, improves

circulatory power, diminishes the frequency and increases the force of the pulse, calms delirium, promotes natural sleep, sustains the faltering powers of the organism, and so tides it over the crisis through which it is passing.

All this is so well known by those conversant with disease and its treatment, and is supported by such a mass of credible and indisputable testimony, from all ranks of the profession, that blunt denials or counter arguments of a technical or theoretic kind, fail to subvert it.

473. Among the beneficial effects of alcohol in moderate doses, and taken with the food, its action on the digestive organs deserves notice. Dr. E. A. Parkes, F.R.S., who is an excellent authority, says: "I have two observations on this point which seem to be really exact. A relative of my own, and a man of singularly good judgment and honest mind, was a total abstainer for many years. When he was between fifty and sixty years of age he got out of health; his digestion became feeble; he ate less, and began to get thinner. He was advised to take one-half to one pint of beer with dinner. He did so unwillingly, but found to his surprise that he ate more, digested better, and soon recovered all his lost ground. He has continued to take beer once a day, and occasionally one or two glasses of wine, ever since. He is now seventy years of age, very healthy, and has no doubt that he has been greatly benefitted by this alteration in his diet."

We have here to remark that while with many persons, so large a quantity of ale or beer would disagree, a much smaller portion, even a wine glass or two, which would not affect the brain, would be productive of similar advantage in debilitated states of the digestive organs; the explanation of which appears to be, that these beverages, though not in themselves foods, in the strict sense of the term, nevertheless, in some way, aid in the digestion and assimilation of foods proper.

Dr. W. B. Carpenter, author of "Use and Abuse of Alcoholic Liquors," bears testimony to this as follows: "There is another class of cases, in which we believe that these malt liquors, either beer or pale ale, constitute *a better medicine than could be administered under any other form;* those, namely, in which the stomach labors under a permanent deficiency of digestive power, consequent either upon original debility or upon persistence in some unhealthful system during the preceding part of life."*

Within a few years, Dr. Carpenter confirmed the foregoing, from his own experience, in a letter to Dr. Parkes, which he permitted him to publish, as follows: "After having been a water drinker during all the earlier part of my life, and enjoying a fair measure of health and vigor, I broke down about ten years ago, under the

* Scottish Review, No. 1, p. 24.

pressure of excessive work, and besides a local disorder, I then suffered from a total loss of appetite and enfeeblement of the digestive power, so that my whole system was rapidly lowering. My medical friends recommended me powerful tonics combined with three glasses of sherry daily, and on this regimen I improved even more rapidly than they expected, and was able in a months' time to enjoy a tolerable dinner, gradually reducing the quantity of wine I took with it. . . . . Ever since that time I have taken a couple of glasses of light claret with my dinner, and this fluid suits me very well. I often reach home very tired and feeling as if I could eat nothing, and I am certain that without this little 'fillip' I should eat nothing. The question lies, therefore, in such cases, between the use of the slight alcoholic stimulus and the inadequate nutrition of the body, and I cannot myself doubt which is the least of what I am willing to admit to be two evils."

Dr. Parkes adds, "coming from such a man, this evidence seems to me indisputable; and coupled with that derived from watching patients with weak digestions, I think may be called conclusive."*

474. Dr. B. W. Richardson quotes some experiments made by Dr. Parkes and Count Wollowicz, in which it is shewn that in "a healthy young adult man," a course of alcoholic administration, (extending over six days, during which the daily dose was increased from one ounce of alcohol on the first day, to eight ounces on the sixth,) increased the action of the heart on the last day at the rate of 25,000 beats beyond what is natural; thus causing it to perform extra work equal to lifting twenty-four tons weight one foot from the earth.

This is a very striking illustration, and one well calculated to impress the popular mind, as it was no doubt intended to do. But there is a fallacy underlying it, which requires no very keen penetration to discover. It is, that under the circumstances, *the heart, indeed, beats faster, but its beats are feebler;* and the feeble beats, oftener repeated, really accomplish no more than slower and more forcible ones. Just as in a pump, with a defective valve, you must work it faster, two strokes for one, in order to procure the same quantity of water as the pump formerly supplied at the ordinary rate of working.

475. The quantity of blood to be propelled by the heart, in a given time, is definite and uniform, although subject to great variation in its rate of propulsion, from various causes. In its normal healthy state, the heart can accomplish its work by a rate of pulsation averaging 73.57 strokes per minute. When the vaso-motor nerves are stimulated by the early effect of alcohol, and the arteries dilate in consequence, the coronary arteries, in common with others, share in the excitement, and convey increased blood to the

* Braith. Retrospect, January, 1875, p. 116.—From the Lancet, 1874, pp. 722, 758.

heart muscle and the motor centres it contains.* The result is felt in increase of the frequency and force of the heart's action. But when the narcotic effect is produced, and the vaso-motor nerves are depressed, functionally, the muscular walls of the arteries, no longer adequately restrained, close in upon themselves, and in the coronary arteries as well as others, the vascular supply is abnormally diminished; the functional power of the heart is lessened; its "lifting" power is enfeebled, so that *the weight of blood which it ought to propel at a single stroke is divided over several.* Hence, although on the sixth day of the experiment, the heart beat 25.488 times faster than its ordinary rate, the quantity of blood passed through it was precisely the same as before the experiment began; and the tissues and organs of the body were no better, but probably much worse, supplied with blood than before.

476. What is just stated, is not invalidated by the fact, that in the onset of sudden coma and paralysis, from apoplexy, or opium poisoning, and probably also from alcohol, *before the paralyzing effect has reached the semi-independent motor ganglia of the heart,* (§ 243) the pulse is often slow and full, in correspondence to the slow and sterterous breathing which characterizes the same state. So soon as the motor cardiac ganglia are impaired, in the manner already discussed, (§ 246) the action of the heart becomes quick and weak, and progressively so until it becomes imperceptible.

Prof Kuss has this state in view when he writes," but the quickness of the pulse yields no indication as to the state of the circulation, properly so called. If we go back to our study of the mechanism of this phenomenon, we shall understand how the pulse may be quick without the circulation being active; if, for instance, the heart at each contraction sends out less than the usual quantity of blood. So, at the moment of death, the pulse may be very rapid, while the circulation declines."†

Professor George B. Wood, treating of the pulse in general, states: "Indeed, it often happens that debility is one cause of extreme frequency of the pulse. A certain supply of blood is demanded by the functions, and the heart, being too feeble to act forcibly, is driven to excessive frequency of contraction in order to compensate for its want of strength."‡

Sir Thomas Watson, in his admirable Lectures, among a mass of interesting details respecting the pulse, writes: "In disease, the pulse may acquire a degree of frequency which is scarcely calculable by the touch; and the less so, because, *when it is extremely frequent it is also extremely feeble.*"‖ It is needless to multiply citations, for though the heart's action is frequently increased in frequency and in force, this is the result of the agency of a stimulant, and never the effect of narcotism.

*See chapter on the heart and its nerves. †Lectures on Physiol., Duval—Amory, pp. 168-9. ‡Practice of Med., Vol. I., p. 188. ‖Prin. and Prac. of Physic, p. 111.

477. In the experiment in question the stimulating stage of alcohol was far exceeded, and the narcotic effect was early entered upon. This is shewn by the fact that two to four ounces of brandy usually induce narcotism. Dr. Anstie, in his experiments, produced this effect in himself by one ounce and a half of whiskey, taken upon an empty stomach, in the morning; not anticipating the production of "the poisonous results" from so small a dose. The "healthy young man" of the experiment in question, took, daily, during the six days, a quantity of alcohol equivalent to from two and a-half, on the first day, to eighteen ounces of brandy, (1 1-8th pints), on the sixth. He must have been deeply narcotized, when Dr. Ringer's habitual toper was rendered "dead drunk" from twelve ounces. There can, then, be no doubt, as to the fact of narcotism, during the greater number of the six days during which the experiment lasted. Dr. Anstie says, "ordinarily the first poisonous effect of a narcotic upon the circulation is considerably to *increase its frequency and to diminish its strength.*" What is here said of narcotics generally, tallies exactly with what Dr. Anstie subsequently states of the narcotic action of alcohol.*

478. What is the legitimate conclusion from these facts? That in a state of daily and profound narcotism, the heart beating with increased frequency, but with diminished force, *it could not*, on the last day of the experiment, have lifted twenty-four additional tons weight of blood, in excess of its ordinary task; for to have accomplished this, it would require to act not only with increased frequency, but also *with increased force;* both of which conditions are impossible under the circumstances. As a matter of fact, then, the heart actually "lifted" no more in the twenty-four hours than it was accustomed to do, but it "lifted" in lesser quantities, and its lighter loads were more frequent. The effect of alcoholic narcotism, on both the mental and bodily organs, is surely bad enough, without seeking to intensify it by needless exaggerations, which, in the long run serve only to defeat the object intended.

479. The argument sought to be drawn by Dr. Richardson from these experiments is valid against the use of alcoholic liquors, in large doses, by persons in health, and that is all. It proves nothing against the judicious use of the drug in moderate doses, in the lesser or graver ailments to which the organism may be subjected. For, as already pointed out, the action and effects of alcohol in disease are of an entirely different character from those in health.

480. We trust these remarks will not be construed to imply that we mean to justify or defend the use of alcoholic liquors indiscriminately or without obvious necessity. It would be well for mankind if so potent and dangerous a drug were restricted solely to its chemical and medical uses. All the medical authorities agree that

*Stim. and Narcot., pp. 202, 353.

it is injurious to persons in health; and that its irregular and untimely use, especially, is disastrous to the well being of the bodily organs.

481. Dr. B. W. Richardson, however, goes further than most of his medical contemporaries, and asserts that at all times and under all circumstances, it is not only of no advantage but that it is essentially poisonous and hurtful. In supporting this thesis, he entirely ignores a large mass of facts, establishing its value under proper restrictions, and in certain abnormal states of the system. In his zeal he oversteps the bounds of legitimate argument, and strains his facts and draws inferences which the premises do not warrant, thereby inflicting injury on the cause he intended to serve. The argument based on the experiments of Dr. Parkes and Count Wollowicz just referred to, is an example of this. Another is to be found in his later assertion, that alcohol coagulates the fibrin of the blood while still circulating in the vessels. His words are, "If the alcohol be taken in very great excess indeed, it causes in the blood coagulation of the plastic part or fibrin. The fibrin, under these circumstances, becomes solidified in the blood-vessels, and so charged, stops the current of blood through the vessels. . . . . Some foolish man, for a wager, or other silly motive, has swallowed, straight off, a large draught of strong spirit, and thereupon has died on the spot. In instances of this nature the blood may be affected by the poison in a few seconds, and the whole of the blood in the heart be made a semi-solid mass or clot, by which the circulation is absolutely stopped and death is rendered inevitable."*

Now, the argument might have been rendered quite as cogent, and the closing scene equally tragical, had Dr. R. confined himself to the true pathology of the case, instead of ignoring the primary facts of science. Would it have been too much to have expected him to consider that alcohol primarily and chiefly assails the nervous tissue, that it paralyzes this tissue,† and that paralysis of the nervous centres affords an equally adequate and perhaps more natural explanation of the cause of the sudden death referred to. Similarly sudden deaths sometimes occur from drinking ice water, and from a severe blow on the stomach, which are accounted for through their effect on the nervous system. Where the heart has been paralyzed and unable to contract upon its contents, it is no unusual thing to find that the blood it contained has coagulated after death. By what right is it assumed that the heart clot referred to, was of ante mortem formation, and was itself the cause of death? Properly speaking, fibrin does not exist, as such, in the circulating blood at all,‡ and is only formed after the blood is withdrawn from the circulation, by the union of albuminous constituents of the blood.‖ Under the circumstances, to refer to the coagulation of

* The Temperance Reader, pp. 158, 159. †Dr. Carpenter, before cited. ‡Dr. Burdon-Sanderson, Hand-book for the Physiol. Labor., p. 183. ‖Ibid, p. 179.

fibrin in the vessels and heart, during life, is not only wanting in scientific accuracy, but is an assertion, we venture to say, unparalleled in the annals of pathology, and entirely unwarranted in fact.

482. The endothelium, or lining membrane of the blood-vessels, exerts a peculiar influence in preventing coagulatory changes in the circulating fluid. This is shewn by the fact that a quantity of blood may be arrested for days, in the jugular vein, (by careful pressure on two points of the vessel, at a convenient distance,) without becoming coagulated, and on removing the pressure, the normal circulation is restored. If the endothelium has been injured, the case is different, and coagulation occurs, owing to changes of its tissue, not unlike those which form the chief cause of thrombosis, in which the calibre of the vessel is reduced preparatory to its occlusion.* Embolism, too, has its source in vegetative alterations of the lining of some part of the vascular tube; but as in the case of the sudden death from alcohol, referred to, there is no pretence that tissue change occurred, for which indeed there is no time, any reference, by comparison, to cases of thrombosis or embolism, in justification of the above assertion, is impossible.

483. Dr. Beale, who has perhaps gone further than any other physiologist in attributing to alcohol an influence over the blood, states, "Of course, when absorbed by the blood of a living person, alcohol does not *coagulate* the albuminous matter."† Dr. Anstie‡ denies the possibility of alcohol in "the thousand-fold dilution," in which it exists in the blood, producing even such comparatively moderate effects as those referred to by Dr. Beale. How much less can it affect the solidification of the blood in the manner referred to by Dr. Richardson!

484. In the very next lesson of "The Temperance Reader," from which we have quoted above, the same writer, with strange inconsistency, founds a new argument against alcohol, on the ground that "in most persons who indulge freely in alcohol the blood is thin, etc."; and again, "Alcohol, when it is freely diluted, acts as I have already said, on the fibrin of the blood, rendering the fibrin *unduly fluid*."‖

Now, this statement, though as inaccurate as the former one, will have a widely different effect on the "reader," who, if disposed to relinquish his potations from fear of a heart-clot, will very naturally conclude that so long as alcohol thins the blood and renders the fibrin fluid, the danger after all is not very imminent.

485. In his latest work, "Addresses on Total Abstinence," just issued, we understand Dr. Richardson to admit the utility of alcohol in certain cases, as an antispasmodic, as a febrifuge, as a remedy in the early stage of phthisis, in deficient surface circulation and in shock;§ but he does so with apparent reluctance, and, as it were,

* Dr. Bastian, Paralysis in Brain Diseases, &c., p. 22. † Disease Germs, p. 420.
‡ Stim. and Narcot., pp. 238, 380, 384. ‖ Pages 162, 163. § Pages 30, 31.

under protest. He makes no attempt to explain how alcohol acts beneficially in any of the cases referred to; nor does he endeavour to reconcile this beneficial action with his other assertions in the same work, of its utter uselessness, or positive injury, to the system in all cases.

This is not what was to be expected from such a source; while the graver errors referred to, are the more to be regretted in the champion of a noble cause, because they weaken confidence in his other arguments, which, unfortunately, are not wholly free from the taint of a too zealous partizanship.

482. We have now a question to ask. If a small dose of alcohol be a stimulant, and induces relaxation of the peripheral blood-vessels, as will be universally admitted, how is this accounted for on the theory now in vogue? On that theory, stimulation of the vaso-motor or vascular nerves contracts the arteries; and the relaxation of these is depending upon nervous paralysis. The organism is stimulated, and as the nervous system is primarily influenced by alcohol, the vaso-motor nerves must be stimulated also. This ought to secure contraction of the calibre of the arteries. But instead of being contracted they are relaxed, as seen by the injected capillaries and flushed face. The result is in antagonism with the theory. Is the organism at fault, or does the theory fail to meet the conditions of this very ordinary case? We assert that the theory is wrong; that stimulation of the vaso-motor nerves and relaxed arteries go together, as do also paralysis of the nerves and arterial contraction.

483. We have dwelt lengthily on this subject, both from its intrinsic interest and importance, and from a desire to show that our theory is not without advantages in its simplicity and adaptation to explain the phenomena of stimulation in the early stage of the administration of alcohol, with its increased motor and vaso-motor activity, dilated blood-vessels and heightened temperature: and also the phenomena of the second or narcotic stage, with its progressive paralysis of the nervous system, its mental incoherence, loss of muscular co-ordination, arterial contraction, weakening the heart by excluding blood and pabulum, from its tissue; rendering the surface pale and the extremities cold from the same cause; and inducing death itself when the nervous prostration becomes sufficiently profound. All this, we think, appears natural and consistent, and commends itself to candid consideration.

486. It is peculiarly unfortunate that an agent which properly used, is potent for good, should also be made the instrument of immense evil. Some of this evil has been laid,—perhaps not undeservedly—at the door of physicians, who are charged with prescribing it under circumstances which sometimes lead to its subsequent abuse.

In this connection, the late declaration of two hundred and seventy leading physicians of Great Britain, is a document of importance,

and merits, as it is sure to receive, the approval of physicians everywhere. While declaring themselves "unable to abandon the use of alcohol in the treatment of certain diseases," they are yet of opinion that "in whatever form, it should be prescribed with as much care as any powerful drug, and that the directions for its use should be so framed as not to be interpreted as a sanction for excess, or necessarily for the continuance of its use when the occasion is past."

It is unnecessary for us to pursue this part of the subject further. The medical profession, to which we address ourselves, are not behind others in the community in aiding in suppressing the vice of intemperance, both by precept and example. Medical authority is unanimous that to persons in health alcoholic liquors are not only not necessary but are injurious, and more especially so in the irregular and untimely manner in which they are usually taken. If the public could realize this fact, and shun the fiery fluids, often greatly adulterated, to which a false sociality too frequently invites them, they would gain immensely in mind, body and estate.

487. *CHLOROFORM AND ÆTHER*,—(as stimulants).—The general action of these agents having been already referred to, (§ 35, 95, 105, 416, etc.) very little is necessary here as to their purely stimulant effects, which, as before remarked, occur early in the process of inhalation and are of comparatively short duration. "During the very earliest inspirations and before the slightest degree of true anæsthesia is produced," chloroform inhalation will sometimes relieve a severe tic. "This is its true medicinal action, and it is certainly a form of stimulation." In other cases of this painful affection, no impression will be made on the pain until unconsciousness arises from its narcotic effect, and the sensory nerves are paralyzed.*

488. In this first, or stimulant action, chloroform inhalation is a very efficient remedy for temporarily arresting spasms and convulsions of every kind, (§ 95, 105.) Here, we claim, nerve-force is developed in increased quantity, or rendered more active, and consequently more capable of restraining the inherent tendency of the muscles to pass into a state of contraction. On the contrary, in extreme narcosis from these agents, when both cranial and spinal nerve centres are paralyzed, and nerve-force suspended, spasms and convulsions are prone to occur.†

489. Dr. Anstie speaks highly of the anodyne effects of fifteen minims of chloroform, inhaled at the commencement of each pain in parturition. He has seen the previously weak and irregular pains become strong and active, and at the same time the suffering of the patient much diminished.

Chloral Hydrate is very effective in this way, in mitigating the suffering of the first stage of labor when little progress is being

* Dr. Anstie, Stim and Narcot., pp. 331-2. † Ibid, p. 124.

made, and the patient is in danger of being weakened and worn out by the unavailing suffering. It is the *anodyne*, and not the stimulating effects, which are here sought; a purpose for which the soothing qualities of opium or morphia, in small doses, are often resorted to.

490. The narcotic, or anæsthetic effects of chloroform in labour, favours relaxation of the outlets from the womb, but has the disadvantage of sometimes inducing uterine inertia, by which the process is prolonged, and also of predisposing, for the same reason, to post partum hæmorrhage.

This behaviour of a paralyzing agent towards the uterus would seem to be a fact hostile to our theory; for in the paralytic stage of chloroform inhalation, the uterine muscle might be expected to be liberated from motor nervous control, in the manner we have predicated of ergot, and its contractile power left free to act with greater power because no longer restrained. But there is no proof that the spinal cord or its motor nerves are paralyzed, in ordinary normal chloroform inhalation. All the effects of that state may be fully accounted for by the paralysis of the cranial centres. When the cord, too, succumbs in extreme narcosis, we have spasms and convulsions of the muscles. The effect of chloroform narcosis, short of this extreme stage, is shewn in muscular relaxation, owing to the cord and its nerves retaining and exerting their control over the muscles; and they do this all the more effectually since the inhibitory power of certain parts of the brain over the spinal cord centres is withdrawn during the narcosis of the cranial ganglia, leaving the cord free to act on the muscles with increased power. (§ 29, 36.)

491. Unlike alcohol, chloroform and æther pass rapidly out of the system. They are therefore not at all adapted to sustain it in certain conditions of exhaustion, in the manner alcohol does, and serve only a temporary purpose.

492. Chloroform or æther is sometimes combined with other remedies in the treatment of paroxysmal or violent coughs. A few whiffs will often be of use in asthma. A small quantity inhaled from the palm of the nurse's hand will promptly arrest the paroxysm of whooping cough. It is sometimes combined with soothing lotions, and favors the absorption of these through the skin. It is seldom administered internally, as other stimulants are generally more readily procurable, and are equally advantageous.

CONCLUSION.—We do not propose to further extend these pages at present. They have already far outgrown our original intention. Enough has been written to present the subject of this essay fairly, though imperfectly, before the reader; and it now awaits his approval or condemnation.

The opinions here expressed, should they see the light, will no doubt excite adverse criticism: for prevailing theories and preconceived opinions are with difficulty relinquished: nay, even manifest error dies hard, especially when reputations are bound up with its maintainance in life.

We shall doubtless be accused of many things; among the rest, with boldness in venturing to challenge great names and current opinions; and we may as well in advance plead guilty to the charge; adding in mitigation of sentence, that the expression of the views herein contained seemed necessary in the interests of true physiological and therapeutical science.

Some will treat our pages with silent contempt; others will characterize them as "mere theory," and consequently regard them as unworthy of serious attention. To this latter class we would say, ask yourselves to what extent your present views of the phenomena of disease rest on a foundation purely hypothetical; and how far also the most approved treatment of disease is entirely empirical? If, in the present state of physiological and therapeutical science, some theory be necessary, that surely is the best, which best accords with most of the facts of the case. We put forward this claim for the theory here presented; and ask for it no favor beyond that to which on fair and candid consideration it may be found to be justly entitled; for we know well that if it be true, it will survive adverse criticism, and find abler advocates; while, if it be false, it will sooner or later pass into deserved oblivion.

THE END.

ADDENDA.

Note to § 81, page 40.—We have been asked, by way of friendly criticism, if the converse of what is here stated holds good where the muscle is contracted, instead of relaxed, at the moment when the motor nerve is severed. We do not pretend that the muscles would necessarily remain contracted, after section of their motor nerves, when contracted previously, at least in ordinary cases. During consciousness, mental emotion in man, and in the inferior animals, terror, would doubtless vitiate such a result, by involuntarily causing a reversal of the molecular nerve arrangements, before the motor nerve, or all the motor nerve communications, were cut across. There may also be unknown differences in the character or intensity of the molecular arrangements for inducing contraction and relaxation of muscle respectively, which come into play under such circumstances, and modify the result.

There is, however, abundant proof that muscular contraction, voluntarily induced, continues after the cessation of the action of motor nerve-force. Thus drowning men, not only "catch at straws," but hold them. As is well known, small objects, as gravel, sand, a few hairs or a bit of clothing, seized in the last moments of life, have been firmly retained in the grasp: as have also the bodies of persons drowned together. Those who object to our theory, must explain how the firm contraction of the muscles is maintained in these cases, after the extinction of nerve-force, and before the setting in of rigor mortis: as well as the numerous other instances mentioned in these pages, of post mortem contractions of muscular fibre, as in the arteries and hollow viscera.

Dr. Alfred S. Taylor even intimates the possibility of a dead body being found "still holding to a rope, cable, or oar,"* and elsewhere he writes, "It may be remarked, that muscles, contracted by living force, in the act of dying, do not necessarily become relaxed in death."† If this be true, then what we have predicated of molecular polar nerve-force, when adjusted for relaxation, is shewn to apply also, under certain conditions, to the adjustment of the same force for muscular contraction: that is, that nerve-force maintains a fixedness or permanency in both cases, when not reversed by voluntary impulses from the central motor ganglia.

Note to § 126, page 63.—An additional point of distinction between nerve-force and electricity, is to be found in their respective rate of motion. Thus, nerve-force moves at an average, in man, at a speed of only about one hundred feet per second;‡ while the rapidity of electricity is, of course, immeasurably greater.

* Medical Jurisprudence, 6th Amer. Ed., p. 327. †Ibid, p. 58. ‡Drs. Beard and Rockwell, Med. and Surg. Elec., p. 208.

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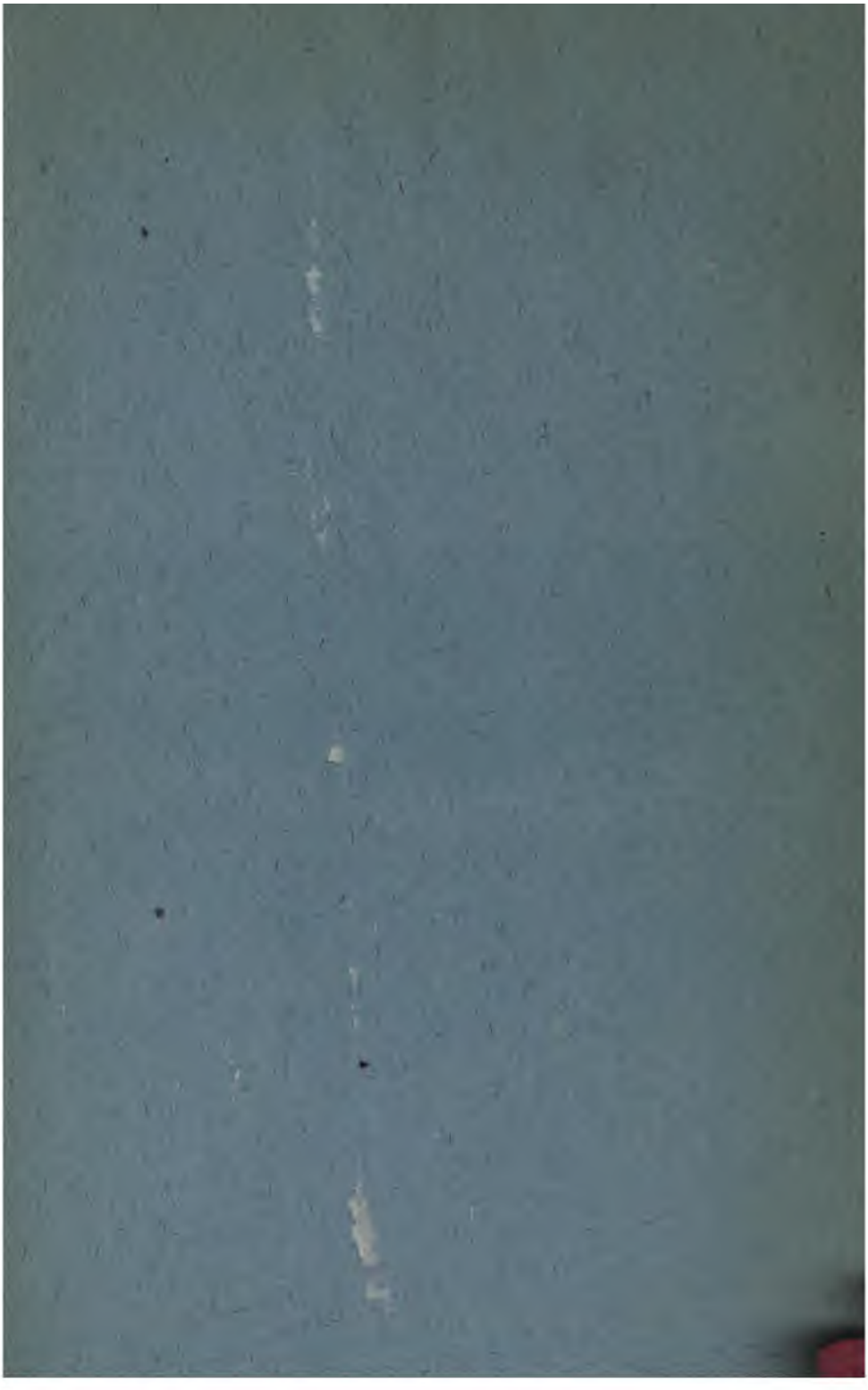


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